UNITED STATES
DEPARTMENT OF AGRICULTURE
U. S. SOIL CONSERVATION SERVICE

May 14, 1956

TO : State Conservationists, SCS
Heads, Engineering and Watershed Planning Units, SCS

FROM : D. A. Williams, Administrator, SCS, Washington, D.C.

SUBJECT: Handbooks and Manuals - Interim Economics Guide

Attached you will find copies of the Interim Economics Guide for use in preparing watershed protection and flood prevention work plans. This guide has been developed to furnish guidance in the economic phases of watershed planning. It is believed that it provides a basis for standardizing basic procedures and will result in more uniform project evaluation.

This guide has been prepared cooperatively by the Washington staff, the economists of the Engineering and Watershed Planning Units and the Agricultural Research Service. It is based on the experience gained in flood prevention surveys and work plan preparation of pilot and Public Law 566 watersheds. It is being submitted in its present form for field testing, review and comment. It will be revised and issued in final form after it has been tested under a wide variety of conditions.

It is suggested that the procedures contained in this guide be considered in the development of future work plans under Public Law 566.

Attachment

D. A. Williams

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3

INTERIM ECONOMICS GUIDE FOR WATERSHED PROTECTION AND FLOOD PREVENTION

INTRODUCTION

The principal purpose of this Economics Guide is to provide a systematic set of currently recognized evaluation practices for use in the economic analysis of Watershed Protection and Flood Prevention Projects under Public Law 566, 83rd Congress (68 Stat. 666), and other project type programs being installed under other Service authorities.

The evaluation methods and procedures outlined in this Guide have been designed to meet existing statutory and Administrative policy requirements under Public Law 566 as well as sound practices for economic analysis of watershed projects.

This Guide is a presentation of methods, procedures and examples for use in making economic studies of watersheds. Since watersheds are usually different in physical and economic characteristics and also vary in the amount and kind of basic data available, it is not always possible to set up a single procedure that can be used in every watershed. Alternative procedures, therefore, have in some instances been included to fit the varied conditions that will be found throughout the United States.

The technical responsibility for making watershed economic studies is that of the economist and in carrying out his work the economist will deal with many basic tools which are a part of his profession. In the chapters to follow, detailed methods and procedures are described, and illustrated with examples, which will be helpful to the economist in carrying out his assigned responsibilities. The adoption and use of these practices by all economists within the Service will tend to assure comparability of results, facilitate review of project reports and result in uniform criteria for formulating projects.

The material presented in the Guide represents the thinking of many persons experienced in the economic evaluation of watershed projects. After a reasonable trial period, or as may be required by changes in policies, suitable revisions will be made.

TABLE OF CONTENTS

CHAPTER 1

ECONOMIC APPRAISALS - USES, FRAMEWORK AND STANDARDS

I. USES OF ECONOMIC APPRAISALS

The primary purpose of benefit-cost analysis, under Public Law 566, is to determine whether or not a proposed project is economically justified. Other equally important uses, however, will be served by economic analysis in the preparation of watershed work plans. The principal uses of these analyses, in addition to that of indicating economic justification, are listed as follows: (1) to indicate the need for improvement measures, (2) to guide project formulation, (3) to indicate the relative economic desirability of different measures and groups of measures and projects and (4) to serve as a guide for cost-sharing, etc.

A. Economic Appraisal - An Indicator of the Need for Improvement Measures.

The first step in the analysis of a given watershed or in the development of a program for the watershed is to analyze the problems of the watershed. This will include one or more of the following determinations: (1) the severity of erosion losses, (2) the losses resulting from sedimentation, (3) the extent and severity of floodwater damage, (4) the restriction imposed upon the use of land by poor drainage, (5) the need for, and problems associated with, irrigation in areas where required to realize full economic agricultural potential of the lands and (6) the need for other agricultural water-management measures. Each of the above determinations, to be of full usefulness, must be expressed in economic terms. Such evaluations, together with standardized cost data, provide a basis for: (a) determining the justification for the project and (b) estimates of the types and amount of justified improvement measures.

B. Objectives of Economic Guides for Project Formulation.

One of the widely accepted principles of project formulation is that measures should be so designed and so grouped that surplus of benefits over costs is greater than for any other design or grouping of measures in attaining objectives of the project. As stated in Section 6 of the Interim Watershed Protection Handbook (hereafter referred to as the Handbook) the application of benefit-cost analysis will guide project formulation to maximize net benefits and aid in selecting the least costly alternative means of meeting project needs. This will require the economic and physical appraisal of a reasonable number of likely alternatives in order to develop a project which will tend to maximize net economic benefits.

C. Degree of Economic Desirability.

A ratio of benefits to costs of greater than one to one is usually regarded as an indication that the proposed work be undertaken. This assumes, of course, that adequate financial and other resources

(either Federal or non-Federal) are available for carrying out the proposed project. Because of the fact that this is not always true, the benefit-cost evaluation should be developed in such a way as to aid in the selection of measures for immediate development and also for the purpose of scheduling future construction. This requires that a number of separate evaluations be made in a given watershed for subdivisions of the measures and subdivisions of the watersheds. The physical interdependence of many measures, however, reduces the number of separate appraisals possible.

D. Economic Appraisal as a Guide for Cost-Sharing.

Two aspects of cost-sharing require the results of economic appraisal. First, the Department's cost-sharing requirements are based in part upon the nature and extent of the benefits involved and whether or not they accrue to public or private interests. The economic analysis may be useful to the local sponsoring organization in its financing and assessment problem, in that it will indicate the classes of benefits and in general the broad groups of beneficiaries who will benefit by the project.

II. APPRAISAL FRAMEWORK AND STANDARDS

The primary function of an evaluation is to provide assurance that effective use will be made of the resources required by proposed watershed projects. To allow making necessary comparisons, project evaluations need to be made in accordance with a set of consistent concepts, principles and standards. A set of guides of this kind form the conceptual framework and the analytical apparatus for making an evaluation analysis. The purpose of this section is to review the basic assumptions and principles that underlie benefit-cost analysis and to indicate general standards and criteria considered appropriate for their application. Aspects covered include principles, concepts and basic assumptions; pricing of project products and services; interest and discount rates and evaluation period.

A. Basic Principles, Concepts and Assumptions.

In common with any type of economic activity, watershed development deals with the production and use of goods and services. Economic goods and services encompass all objects and services that are limited in supply and have the power of satisfying wants. The basic problem in economic evaluation is that of comparing the value of the goods and services produced with that of the costs incurred, after full account is taken of all project effects. In order that results be comparable, it is necessary that uniform standards be used for pricing project goods and services; effects be evaluated from a similar viewpoint; adequate attention be given alternatives; an appropriate basis be used for determining the effects that may be attributed to a project; and consistent assumptions regarding the general economic setting be used.

1. Expression in monetary terms.

In order to make meaningful comparisons, diverse effects must be converted to a common value basis. Beneficial and detrimental effects arise initially in many physical forms, accrue at different times, continue for varying periods, and arise under a variety of circumstances that influence the certainty of their occurrence.

Monetary estimates constitute about the only available means of initially expressing diverse physical effects in terms subject to comparison. Dollar terms provide a yardstick for measuring the relative values of different types of effects at the time of their occurrences. Prices provide a system of weights that may be used to convert various and sundry physical effects to a common dollar value basis. In a market economy, the price system becomes the principal device for bringing about a balanced allocation of resources among competing uses. Prices operate to limit the use of scarce resources and services to meeting needs in accordance with the market rating of their importance. Most watershed projects involve the production or use of goods and services that may reasonably be evaluated in terms of market prices.

However, it must be recognized that the values attached to goods and services by the market may not always accurately reflect values from a public viewpoint. This is due in part to the existence of imperfect markets and the influence of such factors as subsidies, tariffs, price supports and surplus commodities. Also, the market measures only the value of marginal units, rather than the total value of the segment subject to change. While it is extremely difficult to give precise quantitative expression to certain of these considerations, the general principle that project services or products have value only to the extent that they are needed is inherent in any economic evaluation. Despite limitations of the market as a measure of public values, there is no other suitable framework for evaluating in comparable terms the effects of watershed programs or any other type of project. Accordingly, market prices are considered the essential starting point for an economic analysis.

To the extent feasible, project effects which are ordinarily evaluated incompletely or not at all in actual market exchange should be given a derived or estimated monetary value. Types of benefits and costs that cannot be covered by actual or derived market prices still warrant consideration. Intangibles, which are impossible of monetary measurement, need to be weighed and described in a way that indicates their importance and influence on project formulation and selection.

2. Viewpoint applied.

The viewpoint from which the analysis is made must be consistent for the particular purposes to be served by the analysis. The appropriate viewpoint for the evaluation of projects involving

substantial Federal investments is that of a comprehensive National or public viewpoint. Primary emphasis in this viewpoint is placed on taking full account of all significant beneficial and adverse effects. The adequacy of the results obtained depends to a considerable extent on how completely measurement from comprehensive public viewpoint can be realized; that is, how fully all effects on individuals and the public as a whole can be traced and evaluated in comparable terms. The sum of beneficial or adverse project effects accruing to individuals is likely to fall somewhat short of full coverage from a public viewpoint. Types of beneficial or adverse effects that accrue to the public as a whole may not be fully considered in the value judgments of individuals. Examples include the value of resource conservation to future generations; effects on health, welfare and National security; and various other effects that are widely dispersed or not directly apparent to those eventually affected.

Application of a comprehensive public viewpoint often requires making a reasonably sharp distinction between economic feasibility on the one hand, and compensation and reimbursement considerations on the other. The viewpoints involved are basically different. In an evaluation from a public viewpoint, the effects properly subject to consideration include various types of off-sets that arise in other localities or geographic areas. For reimbursement, the appropriate viewpoint is usually local in nature and little attention needs to be given off setting effects outside the area of project influence. In an evaluation from a local viewpoint, the benefit basis for reimbursement might well vary from that available for justifying a project from a National or public viewpoint. Secondary benefits from an area or local viewpoint are likely to be more substantial than from a National viewpoint.

The viewpoint applicable also has a bearing on the standards selected to measure values. The standards for evaluation may vary from those considered appropriate for reimbursement. For example, where reimbursement involves entering into contractual obligations expressed in dollar terms, price fluctuations and trends become much more significant than in an evaluation from a public viewpoint, where the emphasis is on "real" value relationships. While the procedures and standards applied for evaluation should reflect an overall public or National viewpoint, supplemental analyses based on local and regional viewpoints are needed where pertinent for cost-sharing purposes.

3. Least costly alternatives.

Any project or segment under consideration must satisfy the requirement that it be more economical than any actual or potential alternative means available, either public or private, of accomplishing the particular purpose contemplated. No phase of a program should be recommended if a less costly means of accomplishing essentially the same purpose would thereby be displaced or economically precluded from development as a result of the project. Unprecluded ways of obtaining

similar benefits are not a direct limitation on project justification, but rather represent additional projects available for comparison and selection.

All practical alternative possibilities within the scope of watershed program activities should be taken into account. In practice, alternatives subject to consideration are likely to be limited by both area considerations and the information available to the work plan party. Broader bases for establishing project priorities will require consideration at other levels of responsibility including State and Departmental review, review by other Federal agencies and the Bureau of the Budget. During the stages of work plan preparation the work plan party should formulate a proposal that is the most economical of available means of accomplishing the purposes of the program for the watershed under consideration.

4. Ascribing effects to a project.

A uniform basis for attributing effects to a project is needed in order that results be comparable. The generally accepted basis is the "with" and "without" approach, in which the differences in expectations provide the basis for identifying appropriate project charges and credits. It is particularly important that adequate account be taken of expected conditions in the absence of the project, including any corresponding benefits that would be expected from other uses of the project required resources. While the logical basis for the approach is sound, problems arise as to the assumptions that may be considered appropriate for its application. Most of these stem from the lack of an adequate basis for estimates under "without" conditions. The assumptions become particularly significant in the treatment of secondary benefits. The problem is that of deciding what uses would likely be made of project resources, and estimating the effects which would stem from such use. Under full employment conditions, it would appear reasonable to expect that other uses would be made of most goods and services required for project installation and operation. Further, it may reasonably be assumed that the goods and services used for project purposes are normally diverted from the least important uses otherwise expected. Accordingly, the cost in terms of market values usually provides an adequate measure of the value of benefits foregone.

The basis for determining benefits that may be credited to the project is similar. The project should be credited with the difference between project benefits and those expected from applying the resources in some other way if the project were not undertaken. The primary benefits attributable to the project are the total primary benefits, less the cost of the goods and services used that are not otherwise taken into account. As with costs, the value of the benefits

produced is their exchange value, as measured by expected market price at time of accrual.

The "with" and "without" approach becomes an analytical device for determining the effects of various purposes, features and incremental segments both in the evaluation phases of the economic analysis, as well as in project formulation. The amount of credit that is due to any addition (or deletion) in the program becomes the difference in the expected effects with and without the particular change under consideration. In providing a basis for measuring the effects of incremental benefits and costs, the approach is essential to the formulation of projects so as to maximize net benefits.

5. Basic assumption.

Evaluation standards and procedures should be based on consistent assumptions regarding economic trends and expected levels of resource employment. The assumption of a continuously expanding economy for both "with" and "without" conditions would appear appropriate as a general basis for estimating price and requirement expectations. Under such a setting, increasing amounts of goods and services would be required to satisfy the needs of an expanding population and provide for higher levels of living. An eventual demand would develop for all types of goods and services that can be provided at reasonable cost. At the same time, it would be expected that other uses would normally be available for the resources required by the project.

This would result in resources ordinarily being considered scarce in the sense that all would be required under the economic conditions expected to prevail, either with or without the project. Resulting assumptions include the expectation that project required resources would usually be diverted from other uses; such diversions would be from marginal or least important other uses; and values in such uses are measured by market prices.

The high level of resource employment assumption does not preclude consideration of short run fluctuations in the economy. Allowances for unusual local situations need to be included in the analysis of specific projects, with adjustments for general employment conditions made at the National level as considerations effecting the timing and scale of resource development programs.

B. Pricing Project Products and Services.

The prices applied should reflect purchasing power values expected to prevail at the time benefits accrue or costs are incurred. This requires the use of projected prices for all effects occurring over time, including benefits and costs of operation, maintenance, replacement and deferred installations. Current prices or price relationships are appropriate for valuing early installation costs.

1. Projected prices.

The main steps in preparing a set of projected prices consist of establishing an appropriate long-term average for general prices and gearing the price projections for particular commodities and services to that level.

In order to be consistent with other phases of the economic analysis, the general price projection should reflect the expectation of relatively high levels of resource employment, with but a limited range expected in fluctuations around the long-term average. The average general price level used should exclude the effects of inflationary and deflationary trends in the purchasing power of the dollar. Long-term changes in price levels due solely to dollar appreciation or depreciation do not represent "real" benefits or costs in the form of goods and services. Differences between prevailing and projected general prices should reflect expected changes in future levels of resource employment to an extent sufficient to favor development during periods in which resource employment is below average, but still permit purchasing power comparability.

Price projections for specific commodities or groups should be geared to the general price projections, with account taken of particular trends and conditions likely to effect potential supplies and requirements. Use of estimates based on careful consideration of significant factors bearing on future value relationships is likely to prove more adequate than the use of current or historial prices applied without regard for future trends.

The projections used need to be revised periodically as necessary to reflect significant changes in expected levels and relationships. Until revised, the price and cost projections contained in Appendix D should be used in computing benefits and deferred or continuing types of costs.

2. Special pricing problems.

National long-term projected prices require adjustments to reflect area and regional conditions. Usually relationships prevailing between State and National averages during a stable price period provide a basis for State price projections. This involves the assumption that future differences will be the same as during the base period. The State computations contained in the price pamphlet have been prepared by adjusting National projections through the use of National-State base period relationships.

The State projections may require further adjustment to reflect situations in particular watersheds. This usually involves

adapting State projections to the watershed area on the basis of relationships between area and State prices during a base period. The projections used should be consistent for adjoining watersheds separated by State lines, which may at times necessitate the use of average relationships for combined areas and corresponding States. In general, it would appear feasible to make most of the necessary adjustments through applying the conversion factors or price relationships presented in the price pamphlet directly to a comparable year base for the area.

Special consideration needs to be given situations where project production is expected to effect previous price relationships. Where project production is sufficient to cause a shift from a deficit to a surplus production area, such a change would need to be taken into account in the price projections applied. The use of past relationships in market areas comparable to those expected under project conditions may provide a basis for such adjustments.

Other types of special pricing problems include modifications to reflect particular grades or classes of commodities. The price data presented cover averages for either several combined classes, or a principal grade or class. Often these are not adequate for showing price differentials that may be significant for particular watersheds.

For example, the projected price for all hay may not be appropriate where particular grades of hay are likely to be produced. Usually this will require applying the projected price relationship for all hay to the particular classes of hay for which area production estimates have been made. The necessary local base prices may be obtained from Census data, or derived from material compiled by State Statisticians. While the precise steps will vary with the basic data available, usually the conversion ratio for the general class will need to be applied to each subclass for which projections are needed. Similar situations will arise in connection with timber products, vegetables, tobacco and numerous other commodities where grades or class differentials are significant. In such cases, the first step would involve obtaining prevailing or base period prices for each grade, and then projecting on the basis of the conversion ratio for the group.

Products for which price projections have not been computed will need to be estimated on the basis of available projections for the most nearly similar group.

C. Interest and Discount Rates.

Interest and discount rates provide the basis for converting values estimated as of the time of accrual to a common time and risk basis. In an evaluation from either a private or public viewpoint, allowances must be made for any differences in time and uncertainty that

may arise during the period between the investment of resources and the accrual of benefits. Market rates for loans and investments may be regarded as reflecting both "time" and "risk" components. Direct or specific allowances for risks of the predictable type should be made to the extent feasible. This leaves the interest and discount rate as a measure of value differences due to time, together with residual risks and uncertainty.

1. Interest rates.

As with prices for all types of economic goods and services, the need for an interest charge for capital stems from its scarcity. In order to be scarce, resources must be both wanted and limited in supply. The cost to society of capital utilization is determined by the productive opportunities over time that are foregone. In the absence of a direct measure of the productivity of capital, the interest rate on long-term Government bonds is often used as a measure of the minimum risk opportunities of capital. Since the primary basis for the interest charge is the productivity of capital in other uses, a projected long-term average interest rate would appear more appropriate than the rate prevailing at the time of the initial investment. The cost is measured by the expected average productivity of capital in the uses from which diverted.

2. Risk allowances.

The Government rate may be lower than that considered appropriate for a particular project because it reflects the security provided by the general taxing power. Hence, a component often needs to be added to the minimum risk rate to reflect the risks associated with a particular project. Other adjustments for risk may take the form of various types of contingency allowances, conservative benefit estimates, and periods of analysis short of expected economic life. Although most of the risks may be accounted for by such means, there usually remains an element of uncertainty that can be covered only by including a residual risk component in the interest and discount rate used. The amount of the allowance warranted is largely a matter of judgment, since there usually is no actuarial basis for a precise computation. As greater direct allowances are made for risks, the function of the interest and discount rate becomes increasingly that of adjusting for differences of time.

3. Applicable rates.

A generally acceptable basis for converting benefits and costs to a common time basis is through the use of rates applicable to various groups participating in the project. A rate of not less $2\frac{1}{2}$ percent appears appropriate on Federal investments, and not less than 4 percent for private investments. The rate applicable to

non-Federal public investments would be the amount that the organization in question would be expected to pay for borrowed funds. The rate used should ordinarily not be less than the Federal rate, nor more than the private rate. Where benefits need to be converted to a present worth or annual equivalent basis the interest rate used should be based on the degree of certainty with which the benefits will accrue, but should in no case be less than the Federal rate.

While the treatment of interest and discount indicated is not completely in accord with the theoretically ideal basis, it is likely to be more acceptable and induce greater participation in projects. Application of an overall public viewpoint would suggest the use of the same rate for all participants that in turn was based on net costs and preferences after account is taken of off-sets and transfers.

D. Period of Analysis.

The economic life of projects is limited by such factors as deterioration, obsolescence, depreciation, changing needs, and improvements in technology. Discount for time, and risk and uncertainty also limit economic life. The limit is established at that point where the present worth of costs for extension exceed the present worth of the resulting benefits.

Economic life provides an appropriate basis for formulating the scale and scope of projects that serve the public interest. Formulation based on either a longer or shorter period would reduce net benefits.

1. Selected evaluation period.

For purposes of project comparison and selection, it appears desirable to select an evaluation period maybe short of expected economic life. Use of a shorter period provides additional allowance for risks and gives an advantage to projects producing less remote benefits. Accordingly, the period to be used for estimating project benefits and costs should not exceed project life or 50 years beyond the completion of project installation, whichever is less.

2. Evaluation period benefits and costs.

The annual costs chargeable during the evaluation period include amortization with interest of initial installation costs; amortization of an appropriate share of costs of major replacements to be installed during the period; and operation and maintenance costs of a level sufficient to assure effective operating capacity to attain the level of benefits claimed for the project.

The benefits attributable to the evaluation period include those accruing annually over the period, together with any remaining salvage productivity values available at the end of the period. It is expected that benefits computed on such a basis would usually approximate estimates on a project life basis. The principal effect of the use of the evaluation period short of economic life is reflected in increased costs.

CHAPTER 2

APPRAISAL OF FLOODWATER DAMAGE

I. GENERAL CONSIDERATIONS IN DAMAGE APPRAISAL

Damage appraisal is directed toward establishing the relationship between floodwater damages and flood sizes for significant variations in flood plain and hydrologic conditions. There are different methods that may be used to determine these relationships but this basic premise applies to all methods.

II. STEPS IN DAMAGE APPRAISAL

The following outline of steps necessary to adequately appraise floodwater damages is applicable to many varied situations. However, some unusual conditions may require some adaptation of this procedure. Understanding of the principles involved in the application of the normal procedure will provide a basis for making whatever adaptations necessary to cope with unusual problems.

A. Selection of Areas for Study.

To obtain statistically reliable data in watersheds covering only a few square miles, it will be necessary to obtain information on the entire flood plain. On larger watersheds a sampling procedure should be employed when practical.

The first step in selection of a sample for detailed investigation is a careful reconnaissance of the whole area to be studied so that all conditions will be sampled. Stereoscopic analysis of flood plain photographs will be useful for this purpose.

The selection and use of appropriate stream and flood plain reaches provide a means for (a) identifying the location of damages and benefits; (b) bringing the evaluation of hydrologic and economic data together for determination of stage-area-damage relationships; and, (c) relating damage reductions or other benefits to works of improvement.

In setting up the sample of areas for detailed investigation, attention to these points is important:

1. Important variation in flood plain characteristics and in land use should be considered. (An example of this would be where a flood plain crosses two or more problem areas.)

2. Both sides of the stream should be represented.

3. Differences in channel size and valley width from the headwaters to the bottom reaches should not be overlooked.

4. Portions of the flood plain should not be excluded from the possibility of being drawn in the sample for any reason.

5. The selection be such as to facilitate separate evaluation of individual or groups of structures.

B. Collection of Basic Data.

1. Maps.

Major land use in the flood plain will be mapped on aerial photos. This map will also show improvements such as roads, buildings and bridges subject to damage. Land use capability classes and soil delineations may also be shown on the flood plain map. It is usually not necessary to show crop distribution throughout the flood plain, however, it will be desirable to show crop distribution in a few representative sample cross sections in the flood plain. Locations of areas significantly affected by flood plain scour, deposition and streambank erosion may be delineated on aerial photographs.

2. Cost and price data.

The cost estimates obtained from the farmers are seldom adequate because farmers usually consider only their own time and out-of-pocket costs. Cost of farm operations affected by flooding may be calculated by use of such production cost data as shown in Tables 1 and 2. The data shown in these tables should be converted to projected long-term prices before using. If a given operation, such as combining, is usually done on a custom basis in a community, it is recommended that the custom price be considered as the cost of the operation. Usually this type of data is available from State Agricultural Experiment Stations.

3. Collection of information.

Information covering damages experienced by operators of flood plain lands may be obtained and recorded on a flood damage schedule similar to the sample. The schedule will furnish the basic data for estimating damageable values and rates of damage for all classes of agricultural property.

Usually a farmer can give information about one flood, perhaps the largest or the most damaging flood that he has experienced. However, information should be obtained on as many floods as is practical. The enumerator should determine as accurately as possible the proportion of the cropland in the various crops. The division of the flood plain between cropland, pasture and woodland can be determined by planimetering the flood plain map.

Most of the information collected through interview with farmers should be in terms of quantities rather than values and their evaluation should be made in the office.

Table 1 - Cost of Farm Operation, Middlestate, Adjusted to 1950 Prices, in Dollars Per Acre Once Over[1/]
(Sample)

Operation	Hours Per Acre	Cost Per Acre: Use of Machine	Power	Labor[4/]	Preliminary Preparation	Total
Baler, Auto-tie, Aux. Motor, Pick-up[2/]	0.43[3/]	1.30	0.47	0.32	0.34	2.43
Combine without motor 6 feet	0.71	1.49	0.76	0.54	0.47	3.26
Combine with motor 6 feet	0.71	2.05	0.76	0.54	0.56	3.91
Combine with motor 12 feet	0.37	2.05	0.51	0.56	0.52	3.64
Combine, self-propelled 14 feet	0.28	2.30	-	0.21	0.41	2.92
Corn binder, 2-row	0.48	1.27	0.66	0.35	0.37	2.65
Corn picker, pull, 2-row	0.77	1.34	1.05	0.58	0.49	3.46
Grain binder, 8 feet	0.53	1.30	0.56	0.40	0.37	2.63
Hay loader[2/]	1.65[3/]	0.41	0.60	0.41	0.24	1.66
Hay rake, side delivery	0.40	0.34	0.38	0.30	0.17	1.19
Mower, pull, 7 feet	0.45	0.38	0.48	0.34	0.20	1.40
Cultivator, pull, 22-row	0.48	0.19	0.51	0.36	0.18	1.24
Disk, tandem, 7 feet	0.53	0.21	0.56	0.40	0.20	1.37
Harrow, spike-tooth, 18 feet	0.20	0.05	0.21	0.15	0.07	0.48
Lister cultivator, 2-row	0.53	0.24	0.56	0.40	0.20	1.40
One-way disk, 6 feet	0.50	0.17	0.54	0.37	0.19	1.27
Plow, gang, 2-14 inch	1.11	0.38	1.19	0.82	0.42	2.81
Plow, gang, 2-16 inch	0.91	0.38	0.98	0.68	0.35	2.39
Stalk cutter, 2-row	0.36	0.19	0.34	0.27	0.14	0.94
Corn planter, 2-row	0.38	0.38	0.36	0.29	0.17	1.20
Cotton planter, 2-row	0.50	0.50	0.49	0.38	0.17	1.54
Grain drill, 10 feet	0.34	0.34	0.38	0.26	0.16	1.14
Lister, pull, 2-row	0.59	0.36	0.63	0.44	0.25	1.68
Chopping cotton (hand)	7.50[5/]	-	-	4.50[6/]	-	4.50

1/ Source: Middlestate Agricultural Experiment Station Bulletin B-350 and B-345, Middlestate Agricultural Experiment Station Bulletin 391, and Agricultural Experiment Station Bulletin 456.
2/ Data are for tons instead of acres.
3/ Tons per hour.
4/ Based on labor charge of 0.75 per hour, except for chopping cotton.
5/ Rate ranged from 5 hours per acre in southwest Middlestate to 10 hours per acre in eastern Middlestate.
6/ Wage rate of 0.60 per hour.

Table 2 - Usual Operations and Costs for an Acre of Typical Crops (1950 Prices) (Sample)

Operation	Equipment	Rate of Perform-ance[1]	Cost per Acre, Once Over	Times Over	Per Acre Total Cost
		Cotton - Eastern Middlestate			
Cutting Stalks	7' tandem disk	0.53	1.37	1.0	1.37
Flat Breaking	2-14" plow	1.11	2.81	1.0	2.81
Harrowing	18'	0.20	0.48	1.0	0.48
Planting[2]	2-row	0.50	2.08	1.0	2.08
Cultivating	2-row	0.48	1.24	5.0	6.20
Chopping & Hoeing	Hand	10.00	6.00	1.5	9.00
Picking, Ginning, Hauling, Bags & Ties		(per pound of lint)			0.12
Poison & Fertilizer		(varies by area)			
		Wheat - Southwestern Middlestate			
One-waying	6'	0.50	1.27	2.0	2.54
Disking	7' tandem	0.40	1.03	2.0	2.06
Harrowing	18'	0.20	0.48	1.0	0.48
Planting[2]	10'	0.34	2.82	1.0	2.82
Combine	12'	0.37	3.64	1.0	3.64
Hauling Grain		(per bushel)			0.04
		Grain Sorghum - Southwestern Middlestate			
Cutting Stalks	2-row	0.36	0.94	0.5	0.47
Flat Breaking	2-14" plow	1.11	2.81	0.5	1.40
Listing (bedding)	2-row	0.59	1.68	1.0	1.68
Cultivating Beds	2-row	0.48	1.24	1.0	1.24
Planting[2]	2-row	0.38	1.88	1.0	1.88
Cultivating	2-row	0.48	1.24	3.0	3.72
Combine	12'	0.37	3.64	1.0	3.64
Hauling		(per CWT)			0.07
		Corn - Middlestate Bottomlands			
Cutting Stalks	2-row	0.36	0.94	1.0	0.94
Flat Breaking	2-14" plow	1.11	2.81	1.0	2.81
Bedding	2-row	0.59	1.68	1.0	1.68
Harrowing	18'	0.20	0.48	1.0	0.48
Planting[2]	2-row	0.38	2.48	1.0	2.48
Cultivating	2-row	0.48	1.24	5.0	6.20
Hoeing & Thinning	Hand	5.00	3.00	1.0	3.00
Picking	Hand	(per bushel)			0.11
Hauling		(per bushel)			0.04
Fertilizer		(varies by areas)			

1/ Hours per acre
2/ Includes seed

Flood Damage Schedule Work Sheet
(Sample)

Name ____________ Years on Farm ____________ Subwatershed ____________ NOTES

Flood of ____________ Acres Flooded ____________ How frequently do floods of this size occur ____________

Acres Flooded by Largest Flood ______

Damage to Crops and Pasture From Flood of Above Date

Crop	Depth	Acres Flooded	Present Acres This Crop	Expected Yield If No Flood	Yield After Flood	Extra Cost Kind	Extra Cost Amount	Expenses Saved Kind	Expenses Saved Amount
Cotton	0'-2'	10	5	200 lb.	150	Replant Extra	10	Picking	50 lbs/ac
Corn	0'-2'	10	5	30 bu.	15	Cultivation	10	Harvest	15 bu/ac
Wheat	2.1'-4'	10	10	15 bu.	10	Combines	10% longer to harvest	None	
Johnsongrass									
Meadow	2.1'-4'	5	15	1 ton	1	None	-	None	
Pasture	4.1'-6'	10	10		No damage				

Other Damage From this Flood

Type	Damage Quantity	Damage Value
Fence	4 rods	
Poultry	12 hens	
Livestock	1 heifer	

Equipment None

Levees None

*Scour 5A/20%

*Bank Cutting ______

*Sediment 5A/25%

Value of Cropland: $100 acre Value of Pasture: $30 acre

Q. What changes in land use have been made due to floods? A. 10 acres of row crops to Johnsongrass meadow.
Q. What changes would be made if the frequency of flooding were reduced by half? A. All of meadow to crops and 5 acres of pasture to crops.
Q. How often do large floods occur? (If the flood described above is a large flood, change this question to small floods.) A. Once in 8 years.
Q. During what seasons are floods most common? A. Large floods: Spring - 1/2; Fall - 1/2. Small floods: Spring - 3/4; Fall - 1/4;
Q. In addition to the loss in yield described above, was there any damage to quality of crops? A. Wheat-weeds because wheat down. (Estimated percent. Docked price of wheat 25%.
Q. What damage did this flood do to roads and bridges nearby? A. Washed out approaches, about 10 loads needed.

*These items may be total damage since he has been on the farm.

C. Appraisal of Selected Types of Damage

The estimates of damage are based upon information obtained in the field. This information constitutes the raw data which must be analyzed and processed before it can be correlated with data worked out by other specialists in the planning party to obtain an accurate appraisal of the effects of the program.

The planning party is faced at all times with the problem of balancing scanty data with the cost and the time required for obtaining and analyzing more complete information. It may be necessary to adopt certain assumptions and to develop short-cut procedures in order to obtain reasonably accurate answers with minimum planning costs. There is a danger that these assumptions may come to be regarded as facts. Short-cut procedures should be adequately tested.

1. Crop and pasture damage.

The floodwater damage that will be sustained by crops and pasture depends upon the damageable value of the crop, the seasonal occurrence and frequency of flooding, and the characteristics of the flooding such as depth, velocity of flow, sediment load and, possibly duration. The damage schedules form the basis of estimating many of these factors.

Percent damage factors are derived for each crop to relate the damage to the season and the depth of flooding. The steps required in the estimation of the percent damage to a given crop at each depth increment of flooding during a given month or season are shown in Table 3. The same procedure will be used for other depths of flooding and for other seasons or months. This procedure should be repeated for each of the crops in the flood plain.

The schedules that can be obtained in most watersheds will not furnish adequate information for determination of the percent damage factors for all seasons and perhaps for all depths, because information can usually be obtained in a creek watershed on only a few floods. The unit economist can assist the planning party by analyzing damage information that has previously been obtained in similar areas and presenting it in the form of general guides. This information, such as is shown in Table 4, is designed to supplement data obtained in the field on a given watershed by indicating over-all relationships and filling in gaps where the field data are inadequate. It is desirable to calculate as many basic percent damage factors for each watershed as possible because of differences among watersheds in duration of flooding, velocity of flow, soil detachability or sediment load.

The major land use may be determined from the flood strip map. The present crop distribution in the flood plain can be obtained by adding the figures shown in the present acreage column from the schedules obtained in the flood plain. Usually it is desirable to adopt the

Table 3. Flood Damage to Cotton, 3' and Over, Spring Flood, Village Creek.
(Sample)

Schedule No.	Acres Flooded	If No Flood: Estimated Yield	If No Flood: Total Production	If No Flood: Price Per Unit	If No Flood: Total Value	After Flooding: Actual Yield	After Flooding: Total Production	After Flooding: Price Per Unit	After Flooding: Total Value	Gross Damage	Expenses Saved	Net Value Alternate Crop	Added Expenses	Net Damage
	(1)	(2) (lbs)	(3) (lbs)	(4) $	(5) $	(6) (lbs)	(7) (lbs)	(8) $	(9) $	(10) $	(11) $	(12) $	(13) $	(14) $
72	40	300	12,000	0.386	4,632	0	0	0	0	4,632	1,782	916	0	1,934
121	10	135	1,350	0.386	521	0	0	0	0	521	162	0	0	359
114	8	250	2,000	0.386	772	133	1,064	0.386	411	361	112	0	10	259
Total	58	228(av)	15,350		5,925		1,064		411	5,514	2,056	916	10	2,552

Damage Per Acre Flooded $44.00

Percent damage 43

Procedure: Column (1) x Column (2) = Column (3). Column (3) x Column (4) = Column (5).
Column (1) x Column (6) = Column (7). Column (7) x Column (8) = Column (9).
Column (10) = Column (5) minus Column (9).
Column (14) = Column (10) plus Column (13) minus the sum of Columns (11) and (12).

Table 4 - Percent Damage to Crops and Pasture by Flood Depth Intervals and Months
(Sample)

Crop	Flood Depth	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Corn	0 - 1.0	0	2	6	20	29	30	25	20	15	15	10	0
	1.1-3.0	3	10	15	30	35	40	45	40	40	25	17	2
	3.1 & Over	5	15	18	40	45	55	70	70	65	30	25	5
Cotton	0 - 1.0	0	0	3	10	20	20	20	20	20	15	10	4
	1.1-3.0	2	2	10	25	45	55	55	55	55	25	15	6
	3.1 & Over	5	5	15	35	55	65	65	65	65	45	25	8
Wheat	0 - 1.0	2	2	5	20	35	40	10	0	0	2	2	2
Oats, Other	1.1-3.0	8	8	10	40	50	60	20	6	6	8	8	8
Small Grain	3.1 & Over	25	25	30	50	65	70	30	8	9	10	20	20
Sorghum	0 - 1.0	0	0	3	10	20	25	25	18	15	15	10	0
	1.1-3.0	2	2	10	25	30	35	40	40	35	30	17	5
	3.1 & Over	5	5	15	35	50	56	57	57	55	38	18	8
Hay	0 - 1.0	0	0	0	5	25	30	35	20	10	0	0	0
	1.1-3.0	5	5	7	10	27	33	37	30	27	20	6	5
	3.1 & Over	10	10	14	18	36	53	53	42	35	30	13	10
Alfalfa	0 - 1.0	0	0	5	10	15	20	20	20	10	5	0	0
	1.1-3.0	5	5	10	15	23	25	25	25	15	10	5	5
	3.1 & Over	10	10	15	30	35	40	40	30	25	14	10	10
Pasture	0 - 1.0	5	5	5	10	10	12	8	4	4	5	5	5
	1.1-3.0	8	8	8	18	18	20	15	6	8	8	8	8
	3.1 & Over	10	10	10	20	20	20	20	8	10	10	10	10

land use acreage at the year planning is begun to represent present conditions. However, if there are obvious reasons for making adjustments to more nearly reflect normal conditions, the acreages should be adjusted.

Probably, in most cases, a uniform land use can be assumed in the flood plain. However, inspection of the flood plain may show a considerable difference in land use between upper and lower reaches of the stream. If this is the case, a different land use and damageable value should be used for the two (or more) reaches. In some cases there may be variations in a given cross section in land use with elevation above the bankfull stage. The acreage inundated first may be woods or idle land on which there is no damage. If this is the case, it should be separated from the acreage damaged by flooding. Generally this can be done by a shift in the acreage inundated-damage curves.

The normal yield which would have been obtained in a watershed had there been no flooding is a hypothetical figure. Flood plains of creek watersheds are so small that accurate yield data from secondary sources seldom are available. Basic data on the yields to be expected in the flood plain can be obtained from the schedules, but these should be scrutinized rather carefully.

There may be a bias in the figures obtained from the schedules as many other things might have happened to reduce the yield of a crop had a flood not damaged or destroyed the crop. The reported yields should be adjusted in the light of knowledge of fertility, farming methods, etc., in the area. The degree of damage from scour and overbank deposition of sediment reported by the sedimentation party should also be considered. Table 5 shows the method of calculating the composite damageable value per acre of flood plain, when uniform land use is assumed.

The damageable value of each crop, determined as shown in Table 5, can be multiplied by its percent damage factor and the products added to give the damage from flooding an average acre of flood plain to a given depth during each season. This is illustrated in Table 6.

The damage rates derived in Table 7 are multiplied by the acreages inundated to various depths for representative stages and crop damage curves, similar to that shown in Figure 5, are developed. Development of damage curves for seasons rather than one for each month is adequate in many cases. This will substitute the development and reading of three or four curves for the twelve otherwise required.

The flood series may be adjusted by dropping from consideration small floods that occur in such close proximity to larger ones during the planting season, that restoration of damageable values would not be possible. Appropriate adjustments are made for floods in other seasons, usually not more than one flood being considered for crop and pasture damage during a season.

Table 5 - Composite Damageable Value Per Acre of Flood Plain
(Sample)

Crop Use	Percent in This Use	Unit	Yield Per Acre of Crop	Production Per Flood Plain Acre	Value Per Unit (Dollars)	Damageable Value (Dollars)
Corn	6.3	bu.	30	1.89	1.24	2.34
Cotton	6.3	lb.	183	11.5	0.386	4.44
Oats	10.5	bu.	33	3.46	0.81	2.80
Wheat	6.6	bu.	18	1.19	2.00	2.38
Hay, (J.G.)	0.3	tons	2.0	0.006	16.22	0.10
Pasture	67.0	A.U.M.	2.50	1.68	2.61	4.38
Misc.	3.0					

Table 6 - Composite Crop and Pasture Damage Rate, per Acre Flooded, by Depth of Flooding, Spring Season (April, May and June)
(Sample)

Crop	Damageable Value Per Acre (Dollars)	Net Damage: Depth 0 - 1.0' (Percent)1/	Depth 0 - 1.0' (Dollars)	Depth 1.1' - 3.0' (Percent)1/	Depth 1.1' - 3.0' (Dollars)	Depth 3.1' and Over (Percent)1/	Depth 3.1' and Over (Dollars)
Corn	2.34	26	0.61	35	0.82	47	1.10
Cotton	4.44	17	0.75	41	1.82	52	2.31
Oats	2.80	32	0.90	50	1.40	63	1.74
Wheat	2.38	33	0.76	50	1.19	63	1.48
Hay, (P.G.)	0.10	20	0.02	23	0.02	36	0.04
Pasture	4.38	10	0.44	18	0.79	20	0.88
Total			3.48		6.04		7.55

1/ Simple average from Table 4

2. Other agricultural damage.

The sample schedule contains spaces for recording such other agricultural damage as livestock losses, damage to fences, farm equipment, farm levees, etc. It is suggested that the physical amount of such damage be recorded and monetary values be determined in the office. One reason for this approach is that if a farmer reports $100 damage to his fences from a flood in 1945, he may be thinking of what it cost him then, or he may have in mind what it would cost him at today's prices. Clarification of this point will take valuable interview time that probably would be spent to better advantage in pinning down other information. A second reason is that when a farmer gives damage in monetary terms, one needs to have a definite understanding of whether he means only out-of-pocket cash costs or such costs plus the value of unpaid family labor or a complete cost including interest and depreciation on farm equipment.

Ordinarily separate curves by seasons for these other agricultural damages will not be needed. Damages of this type may not start until a fair stage overbank is reached. As an example, floodwater will probably need to be at least two feet deep before there is much damage to fences. On the other hand, when infestation by noxious weeds is a problem, damage from this source may begin at a low flood stage. The sampling procedure used for estimation of crop and pasture damage will be applicable to estimates of damage of this type. Expansion of data from the sampled areas to the entire flood plain can be made safely if the sampling has been done correctly.

When irrigation, drainage, or farm levee systems exist in a watershed and are subject to flood damage, they should be given special consideration and evaluated separately. For example, the damage to an irrigation system might consist only of silting up the ditch or washing out a siphon but before repair of such damage could be made the inability to use the system might cause loss of a crop because of lack of water.

3. Non-agricultural damage.

Most of the damage in small watersheds probably will be to agricultural property, with a certain amount of damage to such transportation facilities as roads, bridges and railroads. Occasionally there will be damage to residential, commercial, and industrial property and to parks, schools and the like. Appraisal of these damages will often require special treatment. A random sample of the flood plain cannot be drawn for this purpose, because the areas subject to damage are localized and the concentration of damage per unit of area is high. Appraisal will require specific consideration of each damage area.

A complete enumeration of damages is desirable. This may be impractical in case a large urban area is flooded. In such an event, an adequate sample should be drawn from the flooded urban areas. Schedules of the type shown in Exhibit A of the memorandum to State and Territorial Conservationists by Carl Brown, dated April 20, 1954, can be used for collecting information of this type. At the time this information is collected the damageable value of the property in the flood plain can be inventoried. Information from the hydrologist on elevations in the flood plain will enable the economist to coordinate his information into a depth-damage curve for the non-agricultural damage in the area.

Secondary sources of information such as files of local newspapers will be of value in fixing the limits of floods experienced in the past. Appraisals of damage that they may carry, if the flood is of fairly recent date, will be useful.

a. Roads and bridges.

Nearly all watersheds will have appreciable road and bridge damage. Estimates of this type of damage may be obtained from State Highway Engineers, Boards of County Commissioners, County Engineers, or Township Trustees. Many times, however, such information is incomplete. A County Commissioner may be newly elected and unable to report on the expenditures of his predecessors. Or he may have a certain sum to spend and keep no particular records regarding the proportion spent for ordinary maintenance and that for repair of damage. For this reason, the flood damage schedule carries the question "What damage did this flood do to roads and bridges nearby?". It is believed that this information obtained from farmers will provide a check on the data from other sources. Furthermore, in some areas, farmers go together cooperatively to repair some of the roads and bridges. When this is the case, the full cost of repairs cannot be found in the books of public officials.

b. Railroads.

Information on damage from severe floods to railroad property usually can be obtained from railroad officials. This information, for any given flood, may be subject to some distortion, for the company may make only partial repairs after the first flood, preferring to wait for future floods before making complete restoration. The question also arises, with railroad damage, as to whether or not there is segregation of normal maintenance and flood repair expenditures when less than major floods are concerned. Ordinarily, it is desirable to obtain as much information as possible from local railroad officials to supplement that obtained from company headquarters.

c. Residential.

Flood damages to residences and appurtenances may constitute a large portion of the total flood damage in some watersheds

even though no major concentration of population exists and only a few scattered houses in the flood plain are affected. Wherever feasible, damages to residences should be appraised separately in each case by making inquiry of informed residents. Some district offices of the U. S. Corps of Engineers have compiled schedules of average damages to dwellings and contents when flooded at different depths. These compilations may be very helpful in establishing damage estimates in the larger communities where many homes are flooded. However, where only a few homes are affected by floods such averages should be used only as guides.

A damage form or schedule should be prepared to serve as a guide and a check list in estimating losses. When appraising and recording damages it is important to associate the damage with depth of inundation in order that stage-damage relationship may be established. The schedule sample shown on the following page is indicative of the kinds of information required and with some modification may fit the needs of most watersheds where residential damages occur.

To comply with the need for development of a stage-damage relationship, damage appraisal for several different flood stages is required. The range in flood stage for which damage appraisals are needed, should extend from the point where damage commences to a stage possibly one or two feet higher than the maximum flood on record. Usually the highest stage for which damages are estimated need not exceed that of the 100-year flood.

On streams where flooding of houses is quite frequent, precautions should be taken to determine, (a) if repairs are made following floods and before the occurrence of succeeding floods and (b) if flooded parts of the house are utilized in the normal or "flood-free" manner. When building values are not maintained and when basements, for example, are not utilized for normal purposes because of frequent flooding, account of these conditions should be taken in adjusting damage appraisals downward from the losses which would occur under less frequent flood conditions. However, if flood stages and frequency are expected to be reduced through works of improvement, possible enhancement of residential values should be considered.

4. <u>Other floodwater damage</u>.

There may be flood damage of types other than those described here in an occasional watershed. If so, the damage should not be neglected, although special procedures for its evaluation may need to be devised. Loss of life in the watershed during floods, although not evaluated in monetary terms, should be reported as an intangible damage.

FLOOD DAMAGE - RESIDENTIAL
(Sample)

Watershed ______________________ Reach ________

Location of property: Stream mile ______________ No. __________

Occupant ____________________________ Years Occupancy _________

Damaging floods: No. _______ Dates ____________________________

APPRAISAL OF DAMAGE

Property damaged	Experienced or Potential Floods 1/		
	Extent of damage		
Residence and contents			
(Depth of water in basement)			
(Depth of water on first floor)			
Foundation			
Basement and contents			
Floors and walls			
Furniture			
Personal belongings			
Lawn			
Garage (depth of water)			
Other buildings (depth of water)			
Automobiles (depth of water)			
Other losses			
Clean-up			

Relevant Data:

Type of residence: Frame _____ Masonry _____. Size of residence ____ square feet. Market value of residence $________. Replacement value of furniture $______. For experienced flood describe any emergency activity for prevention of losses or evacuation __________

1/ Indicate the date of experienced floods. Show height of other flood stages in terms of plus or minus depth increments referenced to the experienced flood.

D. Analysis of Data.

1. Stage-damage curves.

The flood stage affects flood damage in two ways. The first is through the area inundated which varies with stage height. The areas inundated by representative flood stages are usually plotted on cross section paper and stage-area curves derived for each evaluation reach. But, in many cases the flood damage varies with the depth of inundation. Part of the added damage with increased depth undoubtedly arises from the fact that velocity increases as depth increases. Therefore, damage factors applicable to specific depths of flooding need to be derived. As a preliminary to making damage determinations, curves are constructed relating the stage and area inundated at various depths. The attached example is taken from Appendix II, Plate 14 of the Pond Creek Joint Study Report. (See Hydrology Handbook for details on their preparation.)

Separate stage-damage curves for crop damage will need to be constructed for each month or season. For example, it may be assumed that the analysis of crop and pasture damage, described in Section C-1 of this chapter, shows that in Reach 1 in the attached inundated stage-area curve for Pond Creek, during a given month, the crop damages for given depths are:

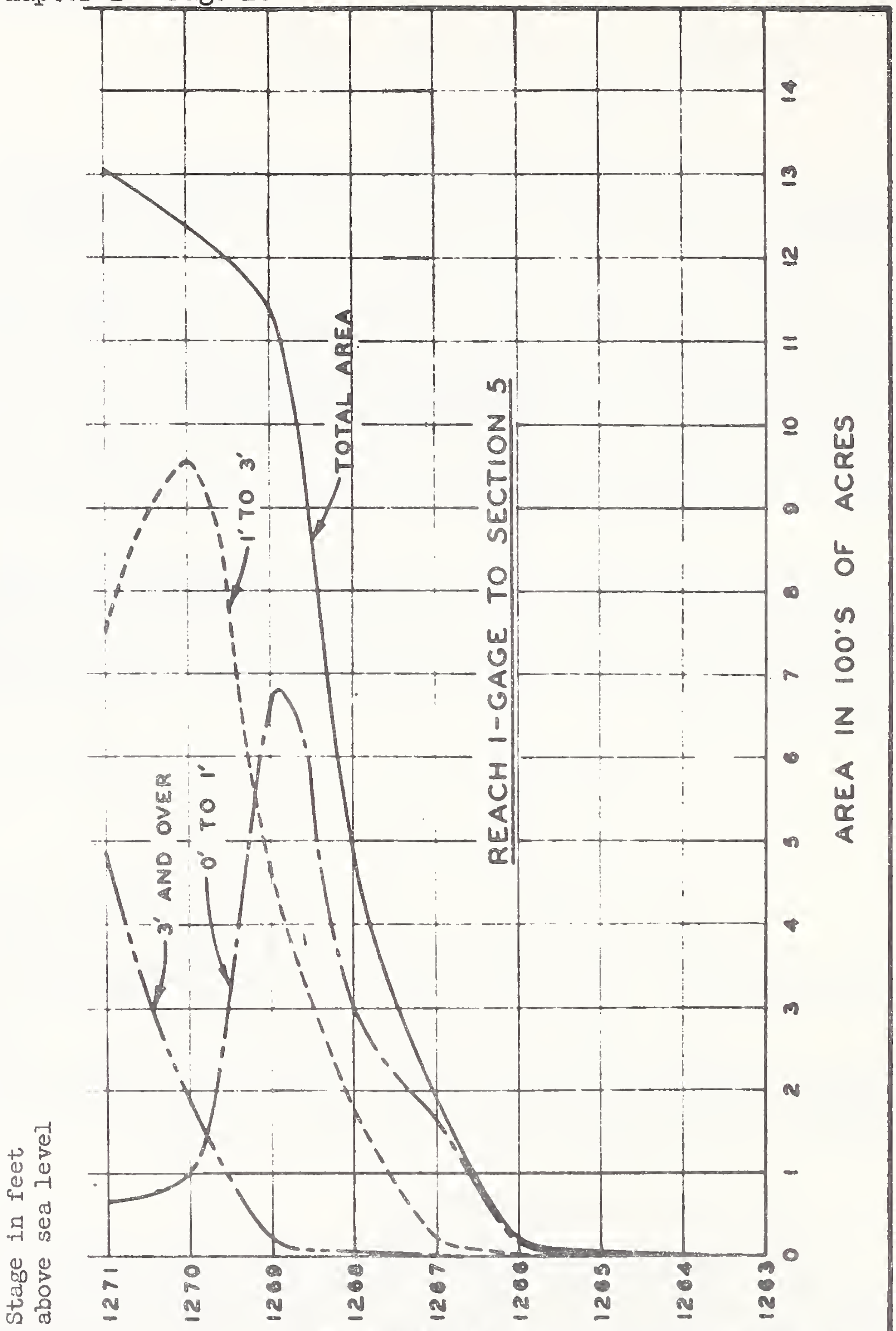
0 - 1 foot	$3.00
1.1 - 3 feet	5.00
Over 3 feet	7.00

When these damage rates are applied to the areas inundated to various depths, the stage-damage curve shown in Figure 1 is obtained.

Stage-damage curves for other agricultural, residential, railroad, highway and similar types of damage may be obtained in like fashion. Ordinarily for damages of these types, separate curves will not need to be constructed for each month or season.

2. Stage-discharge curves.

In order for the economist to relate damage to experienced floods of known size, the hydrologist will prepare curves showing the relationship between flood discharge and flood stage. The procedure for doing this is outlined in the Hydrology Guide. From these curves and the stage-damage curves described in D-1 above, the flood damage for the different floods in the series can be computed.



ARKANSAS-WHITE-RED RIVER BASINS
INTER-AGENCY STUDY
POND CREEK, WASHITA RIVER BASIN
OKLAHOMA

INUNDATED AREA CURVES
VARIABLE FLOW METHOD

SCALE AS SHOWN
APRIL 1952

FILED IN C. OF E.
TULSA DISTRICT
TULSA, OKLAHOMA

AWR 3-32

3. Adjustment for damage recurrence.

Several floods often occur in a single year. In such cases it is incorrect to add the total damage to crops and pasture for each flood and use the sum as the total damage. The first flood will reduce somewhat the value of the crops but in the period between the first and second floods a portion of the value may be restored. One method of calculating these changes in value, and resulting damage, is illustrated in the attached table. This procedure may be used as a basis for derivation of a short-cut formula such as the one being used in Arkansas, Louisiana, Oklahoma and Texas. In the equation $1/Y = 0.8525 + 0.1494X$, X is the total area flooded by all floods in the series, divided by the sum of the areas flooded by the largest flood each year in the series. Y is the percentage of the damage, as calculated from the individual flood events, to be used in correcting for recurring floods. This equation allows for some restoration of value between floods. If an average of three or more floods occur per year during the evaluation series, it is suggested that the equation $1/Y = 0.7706 + 0.2387X$ be substituted. This equation does not allow for restoration of value.

In the four-state area in which it is used, the equation has been tested repeatedly, both in Soil Conservation Service flood prevention operations and in appraisal of Corps of Engineers flood control works. It gives results which seldom differ from those obtained through a flood-by-flood analysis by over two percent. Presumably in other areas of the country where growing seasons and crops are different, a somewhat different equation should be derived.

An example of the correction under the first equation follows: The total acreage flooded by all floods in a 20-year period was 200,000 acres. There was no flood one year and total acreage flooded by the largest flood was 80,000 acres. X therefore equals 2.50. The annual damage found by considering the floods separately was $50,000. Substituting in the formula $1/Y = 0.8525 + 0.1494(2.50) = 0.8525 + 0.3735 - 1.2260$, $Y = 81.566\%$. The corrected average annual damage to crops and pasture would thus be 81.566% of $50,000 or $40,783.

ADJUSTMENT OF ESTIMATES OF CROP AND PASTURE DAMAGE FOR RECURRENCE
TENTATIVE TEST PROCEDURE FOR POND CREEK
(Gross Value of Production - $31.62 Per Acre)

Date of Flood	Depth This Flood	Acres at This Depth	Original Value of Crop	Date of Previous Flood	Depth Previous Flood	Value Before This Flood	Percent Damage This Flood	Dollars Damage This Flood	New Value	Percent of Original Value	Adjusted Flood Damage
			$			$			$		$
1924, Mar. 19	0 - 1.0	111	3,510	None	-	3,510	3.9	138	3,372	96.1	138
Apr. 25-26	1.1 - 3.0-	111	3,510	March 19	0 - 1.0	3,372	24.4	823	2,549	72.6	
	1.1 - 3.0	177	5,597	None		5,597	24.4	1,366	4,231	75.6	
	0 - 1.0	604	19,098	"		19,098	11.9	2,265	16,833	88.1	4,454
June 10	1.1 - 3.0	3	95	April 25-26	1.1 - 3.0	69	42.9	30	39	41.1	
	0 - 1.0	108	3,415	"	1.1 - 3.0	2,479	23.9	592	1,887	55.3	
	0 - 1.0	177	5,597	"	1.1 - 3.0	4,231	23.9	1,011	3,220	57.5	
	0 - 1.0	42	1,328	"	0 - 1.0	1,170	23.9	280	890	67.0	1,913
Sept. 27	1.1 - 3.0	1	32	June 10	1.1 - 3.0	13	33.7	4	9		
	0 - 1.0	2	63	"	1.1 - 3.0	26	14.0	4	22		
	0 - 1.0	108	3,415	"	0 - 1.0	1,887	14.0	264	1,623		
	0 - 1.0	85	2,688	"	0 - 1.0	1,546	14.0	216	1,330		488
1925, Apr. 7-8	1.1 - 3.0	2	63	None	-	63	24.4	15	48	76.2	
	0 - 1.0	277	8,759	"	-	8,759	11.9	1,039	7,720	88.1	1,054
Apr. 23-24	1.1 - 3.0	2	63	April 7-8	1.1 - 3.0	48	24.4	12	36	57.1	
	1.1 - 3.0	148	4,680	"	0 - 1.0	4,123	24.4	1,006	3,117	66.6	
	0 - 1.0	129	4,079	"	0 - 1.0	3,594	11.9	428	3,166	77.6	
	0 - 1.0	361	11,415	None	-	11,415	11.9	1,358	10,057	88.1	2,804
May 31	1.1 - 3.0	2	63	April 23-24	1.1 - 3.0	36	36.4	13	23	36.5	
	1.1 - 3.0	112	3,541	"	1.1 - 3.0	2,358	36.4	858	1,500	42.4	
	0 - 1.0	36	1,138	"	1.1 - 3.0	758	21.0	159	599	52.6	
	0 - 1.0	129	4,079	"	0 - 1.0	3,166	21.0	665	2,501	61.3	
1925, May 31	0 - 1.0	338	10,688	April 23-24	0 - 1.0	9,416	21.0	1,977	7,439	69.6	3,672
Sept. 9-10	1.1 - 3.0	2	63	May 31	1.1 - 3.0	23	33.7	8	15	23.8	
	1.1 - 3.0	112	3,541	"	1.1 - 3.0	1,500		506	994	28.1	
	1.1 - 3.0	36	1,138	"	0 - 1.0	599		202	397	34.9	
	1.1 - 3.0	129	4,079	"	0 - 1.0	2,501		843	1,658	40.6	
	1.1 - 3.0	301	9,518	"	0 - 1.0	6,625	33.7	2,233	4,392	46.1	
	0 - 1.0	37	1,170	"	0 - 1.0	814	14.0	114	700	59.8	
	0 - 1.0	23	727	April 23-24	0 - 1.0	568		80	488	67.1	
	0 - 1.0	845	26,719	None	-	26,719	14.0	3,741	22,978	86.0	7,727
Nov. 6-7	1.1 - 3.0	2	63	September 9-10	1.1 - 3.0	15	11.7	2	13	20.6	
	1.1 - 3.0	112	3,541	"	1.1 - 3.0	994		116	878	24.8	
	1.1 - 3.0	36	1,138	"	1.1 - 3.0	397		46	351	30.8	
	1.1 - 3.0	129	4,079	"	1.1 - 3.0	1,658		194	1,464	35.9	
	1.1 - 3.0	35	1,107	"	1.1 - 3.0	510	11.7	60	450	40.7	
	0 - 1.0	266	8,411	"	1.1 - 3.0	3,877	6.1	236	3,641	43.3	
	0 - 1.0	37	1,170	"	0 - 1.0	700		43	657	56.2	
	0 - 1.0	23	727	"	0 - 1.0	488		30	458	63.0	
	0 - 1.0	303	9,581	"	0 - 1.0	8,240	6.1	503	7,737	80.8	1,230

This correction applies only to crop and pasture damage. Ordinarily the farmer can fix fences and restore the value to most of the other flood damaged property before he can get into his fields after a flood to replant or to cultivate.

4. Indirect damage.

Indirect damages include losses which result from direct floodwater damages. Examples of such indirect damages include an electric power plant being flooded so that power is no longer produced and spoilage takes place in freezers and refrigerators operated by electricity; a bridge washed out and traffic is forced to detour a considerable distance; the flood causes interruption in the feeding regimen of a livestock producer and, although his livestock were not in the flood, the upset slows down the rate of gain and causes extra expense before they are marketable. In estimating indirect damage, care must be taken to avoid double counting. For example, a house may be flooded and the family living there may lose its clothing. This loss is a direct damage, but the value of substitute clothing supplied by a relief agency would not be an additional indirect damage.

In preparing damage estimates, the question of how to arrive at dollar values for indirect primary damages arises. In the past, it has been common practice to assume that indirect damage is some percentage of the direct. By simple application of a percent factor the indirect damage is said to be so many dollars. It is generally agreed that in many cases it may be incorrect to assume that there is a positive correlation between the direct and indirect damage. In order to avoid possible errors in this regard, it is suggested that the following procedures be used in estimating indirect damage:

a. Where time and personnel are available and indirect damages appear important, make an adequate number of sample studies by personal interviews with residents in the watershed to establish a base for different sizes of floods from which to estimate the probable indirect losses caused by floods.

b. By plotting the basic data for the different size floods, it will be possible to draw a stage-damage curve or curves which can then be used to prepare estimates.

c. In those cases where time and personnel will not permit sample studies as outlined in a and b above, it will be permissible to assume that indirect damage is a reasonable percentage of the direct. The indirect damage should not ordinarily exceed ten percent of the direct unless it is documented.

A special casė occurs when there is floodwater and sediment damage to irrigation facilities. Destruction or silting up of irrigation works may easily cause the complete loss in unflooded areas of crops dependent upon the irrigation water. This type of damage may be appraised with little difficulty by means of damage schedules taken in the field.

III. DAMAGE APPRAISAL - OVERLAND FLOODS

In portions of the country, ephemeral streams may discharge their floodwater onto alluvial areas with no defined channel to the main watercourse of which they are tributary. Usually these alluvial areas are flat or only gently sloping in both directions and the floodwater spreads out until the flow is eventually dissipated. This situation wherein there is virtually no channel or where the possibility of lateral spreading is great is called overland flooding.

Under natural conditions, these alluvial areas were natural spreading areas for runoff. Because of favorable topographic and soil characteristics many have been developed into highly productive farming areas and in some cases into urban and suburban areas. The increased value of property and its greater susceptibility to damage, together with the inability of individuals to protect their property because of the unpredictable path of the flood flows, has created serious though local flood problems.

A. Special Problems of Damage Appraisal.

The use of the damage-discharge or damage-stage approach in river and creek valleys is generally accepted as the best method of damage appraisal. This is because floods of given discharge can be converted to flood stage by acceptable flood routing techniques. Peak discharge and flood stage have little meaning in overland floods. When the floodwater emerges from the canyon section onto the alluvial fan or plain the flood peak is quickly flattened. As a result, the area flooded is not a direct function of the peak discharge except as it may overtop diversion dikes built to direct its course away from a portion of the flood plain. More generally, the area flooded is directly related to the flood volume and the greater the volume, the greater is the area flooded.

Overland floods seldom follow the same path. During the interval between floods, even minor changes in the flood plain such as small dikes, road and railroad fills, irrigation ditches or even land levelling have been known to alter the course of flood flows. Sediment deposition where their is an abrupt change of grade is also an important factor in altering their course. These factors suggest that historical damages may not be a reliable index of what may happen in the future.

This problem may not be too important when there is considerable homogeneity of property in various portions of the flood plain.

From the standpoint of total flood damage, it is not too important to forecast whether Mr. Jones or Mr. Smith's cotton crop will be damaged by the next flood. Neither does it matter whether the flood will wash out the railroad again at milepost 362 if instead it washes it out at milepost 364. However, it does make a difference though whether 20 acres of wasteland or 20 acres of urban property is flooded. To predicate a flood prevention program on either condition without regard to alternative probabilities, based on present or anticipated flood plain conditions, is dangerous.

Procedures for dealing with these problems are discussed in the following section.

B. Procedure for Damage Appraisal.

In appraising flood damages from overland flow, it is usually desirable to relate experienced or forecasted damages to floods of known or estimated size. Without exception, small watersheds of this type do not have gaging stations and the estimating of flood sizes imposes special problems on the hydrologist which need not be considered here. For reasons pointed out above, the peak discharge is not important, but the flood volume is. Where little or no ponding occurs, it has been found that there is a good correlation between size of flood (acre feet) and acres flooded.

The relationship is illustrated in the White Tanks Watershed in Arizona. Floodwater from this watershed debouches from the White Tanks mountains onto a highly productive gently sloping flood plain. Once the floodwater breaks through the highline irrigation canal, it spreads out over the farm land in relatively shallow sheet flows except where it is concentrated or obstructed by railroad and road fills, ditches or other man-made obstacles. Seldom does it reach the Agua Fria or Gila Rivers. The relationship between flood volume and acreage flooded is shown in the following tabulation:

Flood Date	Volume acre feet	Acres crop land flooded	Acres flooded per acre foot
Aug. 1939	3,500	4,600	1.3
Sept. 1946	7,000	7,500	1.1
Sept. 1949	2,500	3,000	1.2
Jan. 1951	5,500	7,000	1.3
July-Aug. 1951	11,500	14,100	1.2
Total	30,000	36,200	1.2

It should be noted that in this watershed there is a large area of crop land that lies in the flood plain, not all of which would be

subject to flooding by a single flood, but most of which is subject to the flood hazard by slight changes in the paths of flood flows. Even the 100-year flood would inundate only about 25% of the flood damage area.

In overland flow situations with relatively little ponding, farm damage per acre flooded appears to be relatively constant irrespective of the size of the flood. This is illustrated again in the following tabulation for the White Tanks Watershed for two floods, both of which occurred in August:

Type of Damage	1939 Flood	1951 Flood
Crop	$28.75	$28.60
Land	8.89	10.14
Farm ditches	3.91	3.60
Misc. farm damage	1.69	3.11
Total farm damage/acre flooded	$43.24	$45.45

Since the 1951 flood was over three times as large as the 1939 flood, it was concluded that flood damage was proportional to the acreage flooded, which in turn was proportional to the flood volume. Hence, it was necessary only for the hydrologist to determine a flood volume-frequency series which provided the basis for determining average annual flood damages over a normal hydrologic period.

It might be inferred that this method of damage appraisal does not consider the factor of depth of flooding which has been found to be the most important single factor of damage variation in many cases. This inference, however, is not necessarily correct. Depth of flooding was important to the foregoing example, as shown by damage schedules. Hence, it must be concluded that the mean depth of flooding and the distribution of acreage flooded by depths (percentage wise) was the same regardless of the size of the flood.

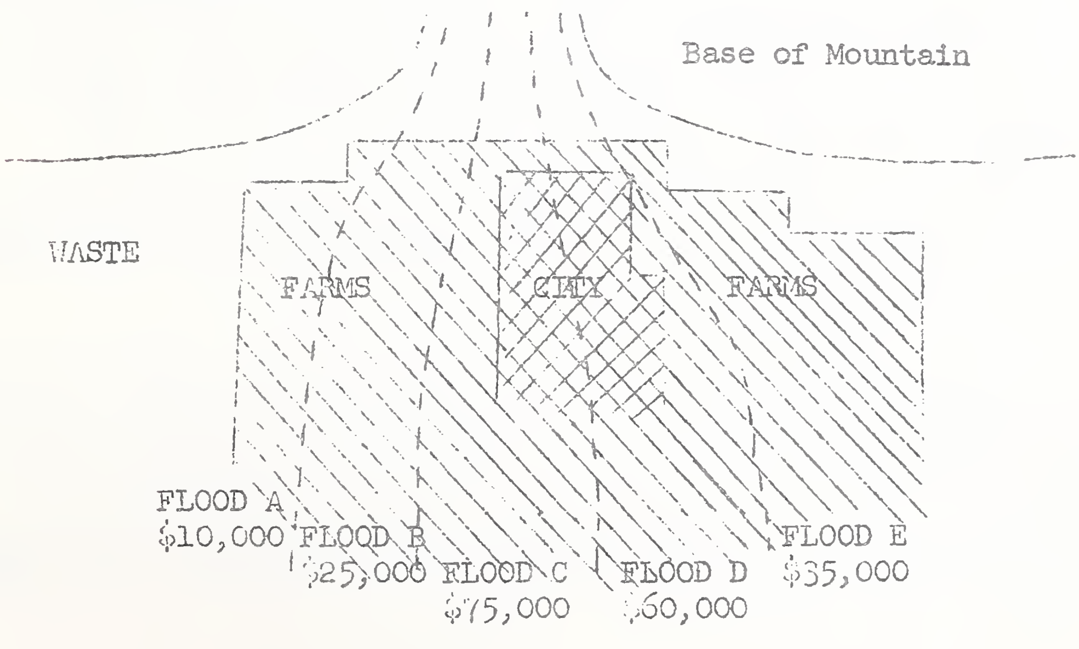
A somewhat different flood plain is found in the Rio Grande Valley in the vicinity of Hatch, New Mexico. Here lateral arroyos discharge floodwater onto the irrigated farm area. In most cases the stream channels have been completely obliterated by farming. Because of the flat terrain of the flood plain, water tends to pond behind some obstruction but seldom is there sufficient flood volume to overtop and break the obstruction. Hence, the area flooded by small floods is almost as great as the area flooded by larger floods. This is in almost direct contrast to the White Tanks situation described above. The principal crop grown in the flood plain is cotton and damage to this crop constitutes the largest single item of damage. An analysis of damage schedules covering flood depths from 6 inches to over 3 feet showed that crop damage was directly related to depth of flooding. Flooding of 10 acres to a depth of 2 feet resulted in about the same damage as flooding 20 acres

to a depth of 1 foot. Hence, cotton damage per acre-inch (or acre-foot) of flooding was concluded to be a constant. Obviously, the cotton damage was directly related to flood volume as it was in the White Tanks Watershed.

Even though the two watersheds represent considerably different flood plain characteristics, it was concluded that flood damages vary with the flood volumes even though the relationship is not necessarily the same in different watersheds. The validity of this conclusion has not been tested sufficiently to warrant the assumption that it will work in damage appraisal of all flood plains where the flood problem is the overland flow type. Because of its simplicity in application, however, it does appear that this method of damage appraisal warrants first consideration in this type of watershed.

It has been pointed out that one characteristic of overland flows particularly where there is little or no stream channel is that paths of such flows cannot be predicted. This is also true of mud flows in some sections of the west. This problem is not particularly important where there is homogeneity in the flood plain. However, many alluvial fans or other alluvial areas exhibit a wide variety of damage potential due to differences in kind and extent of development. If a flood strikes the developed area of the flood plain serious damages may result, whereas if it followed a path through the undeveloped area little or no damage would occur. Hence, it is necessary in such situations to determine the mean damage resulting from a flood of certain size, taking into consideration the probability of the flood following any one of several possible paths.

This problem is illustrated in the following sketch:



Through the use of topographic surveys, aerial photographs, and maps of historical flood flows, flood paths A, B, C, D and E are traced through the flood plain. Flood damages are determined from known relationships between damages, flood depths, and velocity. If a flood of the magnitude being studied has an equal chance of following each of the flood paths then the probable damage from such a flood is equal to the mean value of the five alternatives which in this example is $41,000. Similar studies would be made for floods of different magnitudes which would furnish the basis for damage-discharge curves.

This technique is also adaptable to several subwatersheds having a common flood plain and where centering of storms over the different subwatersheds has a significant effect on flood damage.

IV. CALCULATION OF AVERAGE ANNUAL DAMAGE

Two methods are generally used to determine average annual floodwater damages. These are commonly termed the historical series and frequency series.

A. Historical Series.

The historical series is applicable only when rainfall and the frequency and sizes of floods are approximately normal. Essentially it is based upon the assumption that a sequence of events that has occurred in the past will also occur in the future. Ordinarily floods of extreme magnitude are excluded from the series. This method is generally used where there is a record of stream flow, floods are frequent, and damages are primarily agricultural.

After the various categories of damage have been appraised for each flood under existing conditions, the sum of the damages for all floods during the evaluation should be obtained and divided by the number of years in the period. This will give the unadjusted average annual damage. This figure is then adjusted for recurrent flooding, or other necessary adjustments to obtain the average annual damage.

The same procedure is followed to determine damages after land treatment and after each phase of the program. The difference in damage between the before and after period for each phase of the program represents the benefit for that phase.

Caution should be observed with regard to the evaluation period. It often happens that the period of record of stream gages or rain gages involves fractional parts of a year. Evaluation periods should comprise complete years, dropping all fractional periods from consideration. It should also be noted that unless floods are an annual occurrence an error may be introduced by starting and ending the flood period with floods. For example, flood damages may be estimated for a period of 20 years

(1937 - 1956 inclusive) during which time 7 floods occurred. An examination of the record (or other reliable sources) shows that the last flood previous to 1937 occurred in 1934. Hence the flood period covers 22 years (1935 - 1956 inclusive) rather than 20.

B. Frequency Series.

The frequency series, used in flood damage appraisal, involves the establishment of four basic relationships of flood characteristics. These associations, generally expressed by means of graphs, include the following:

1. Flood stage versus damage.

2. Flood stage versus peak discharge.

3. Peak discharge versus frequency of occurrence.

4. Flood damage versus frequency of occurrence.

Development of these four graphs, illustrated in Figures 1, 2, 3 and 4, makes possible the computation of average annual flood damages for the stream reach covered by the graphs.

1. Stage damage.

Flood damage surveys provide the basis for formulating this curve (Figure 1). The height of an experienced flood is used as the base point from which stages of other experienced or potential floods are referenced. Damages are appraised for sufficient stages to adequately define the shape of the curve. Columns 1 and 2, table 7, illustrate this phase of the frequency method.

2. Stage discharge and discharge frequency.

Derivation of these two graphs required in application of the frequency method of damage appraisal is shown in the Hydrology Guide. Figures 2 and 3 and columns 3 and 4 of table 1 indicate application of these data in the procedure.

The damage-frequency curve, Figure 4, is drawn through the plotted values of corresponding damage and frequency obtained from the graphs described above. The values used in producing this graph are shown in table 1. Average annual damage is determined from the damage-frequency curve by the following calculations:

a. Planimeter in square inches the area enclosed by the curve.

b. Determine the product of the values of the abscissa and the ordinate at the point one inch from the point of origin. This value determined from Figure 4 is obtained as follows: abscissa 1 percent, ordinate $100,000 giving a product of $1,000.

c. Product of the total square inches measured in a (13.39) and unit value per square inch measured in b ($1,000) is equal to average annual damage ($13,390).

The frequency series, as described above, is generally suited to stream reaches where damaging floods are infrequent. In these circumstances, if a significant flood problem exists, the major type of damage usually is non-agricultural. In contrast, on stream reaches where floods are frequent, the major type of damage is usually agricultural. The frequency series offers an approach to computing average annual damages by weighting the effect of all floods without estimating losses separately for each flood in a long series of events, thereby providing an adequate estimate at a saving of work over the historical series method.

In reaches where crops are flooded more frequently than once a year, the damaging effect of the succeeding flood oftentimes is altered by the effects of the previous flood. It is impractical, under these circumstances, to adjust crop damages unless the historical series method is used. Where crops are flooded frequently and damage from this source constitutes a substantial part of the total flood damage, the frequency method should not be used.

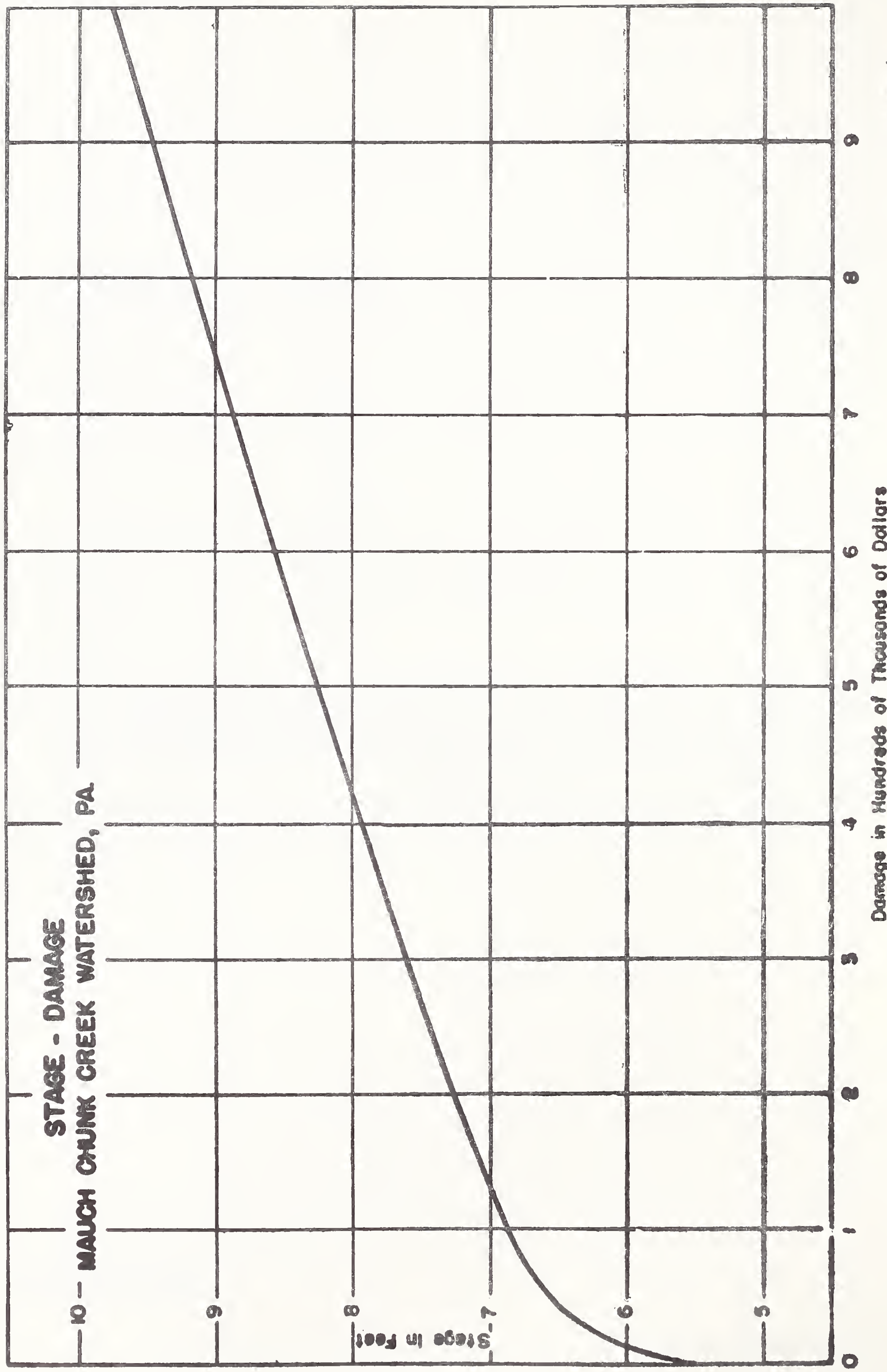
When crop damages are involved in the damage frequency method, it is necessary to make an adjustment in the stage-damage relationship to account for the seasonal distribution of floods. This adjustment is required in order to account for the difference in flood damage resulting from given flood stages during different periods of plant growth. Relative frequencies by seasons or months furnish the basis for making the adjustment. Methods of frequency determination are described in the Hydrology Guide.

Table No. 7 - Reach No. 4 __________Creek

Damages Resulting from Floods of Different Sizes and Frequencies

Flood stage in relation to flood of 6/15/45	Damage	Peak discharge	Chance of occurrence 1/
(Feet)	(Dollars)	(c.f.s.)	(Percent)
+ 2	1,000,000	4,200	less than 1
+ 1	720,000	3,450	less than 1
6/15/45	410,000	2,800	1.4
- 1	110,000	2,000	3.2
-2	10,000	1,500	6.0
-1	0	1,200	7.5

1/ Frequency of occurrence may be expressed in several ways, each of which may be converted to the other. The term used herein should be interpreted to mean the percent chance of a given peak discharge being equalled or exceeded in any one year.



STAGE - DAMAGE
MAUCH CHUNK CREEK WATERSHED, PA.
Stage in Feet
10
9
8
7
6
5
0
1
2
3
4
5
6
7
8
9
Damage in Hundreds of Thousands of Dollars

Figure 1

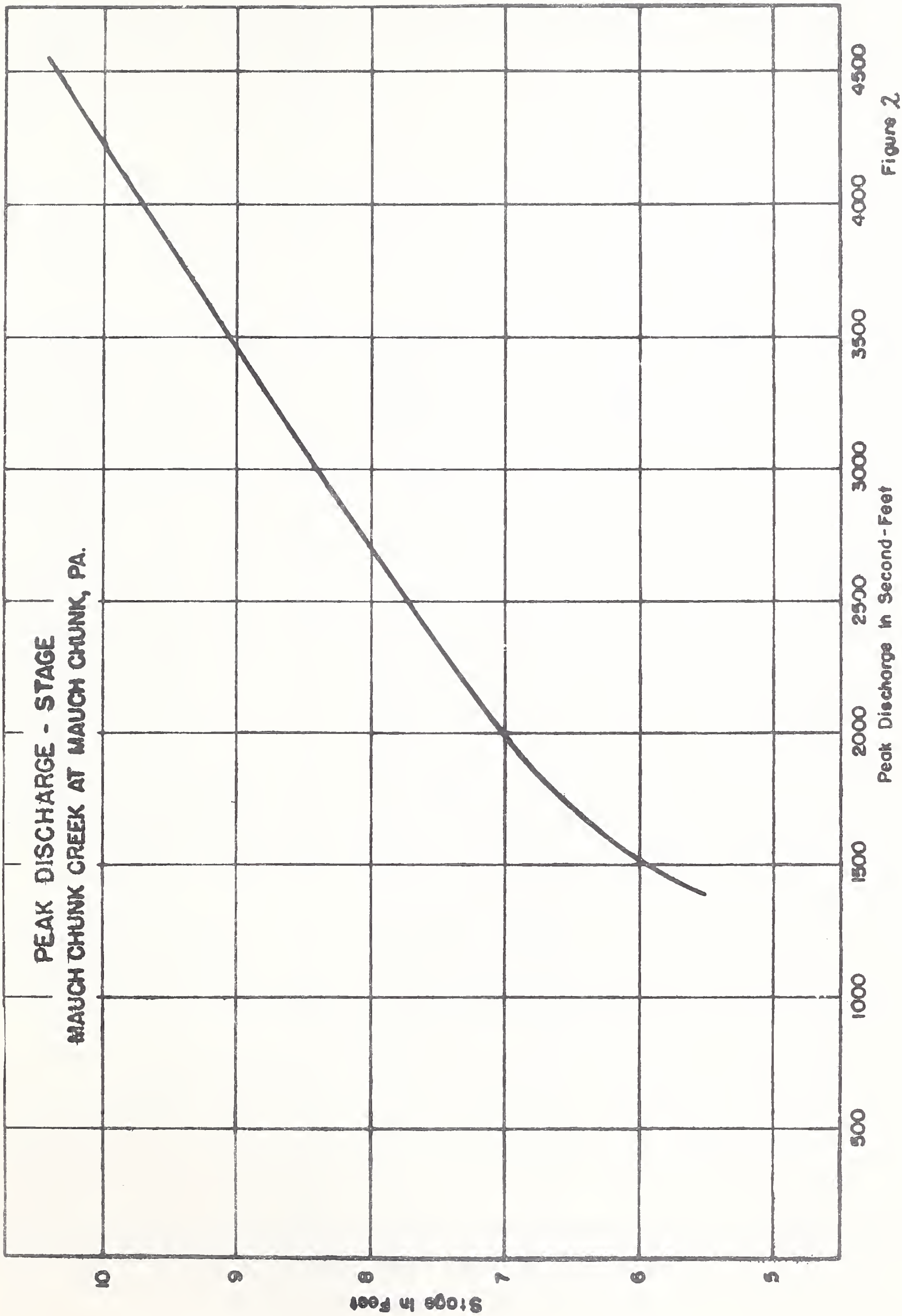

PEAK DISCHARGE - STAGE
MAUCH CHUNK CREEK AT MAUCH CHUNK, PA.
Peak Discharge in Second-Feet
500
1000
1500
2000
2500
3000
3500
4000
4500
Stage in Feet
5
6
7
8
9
10

Figure 2

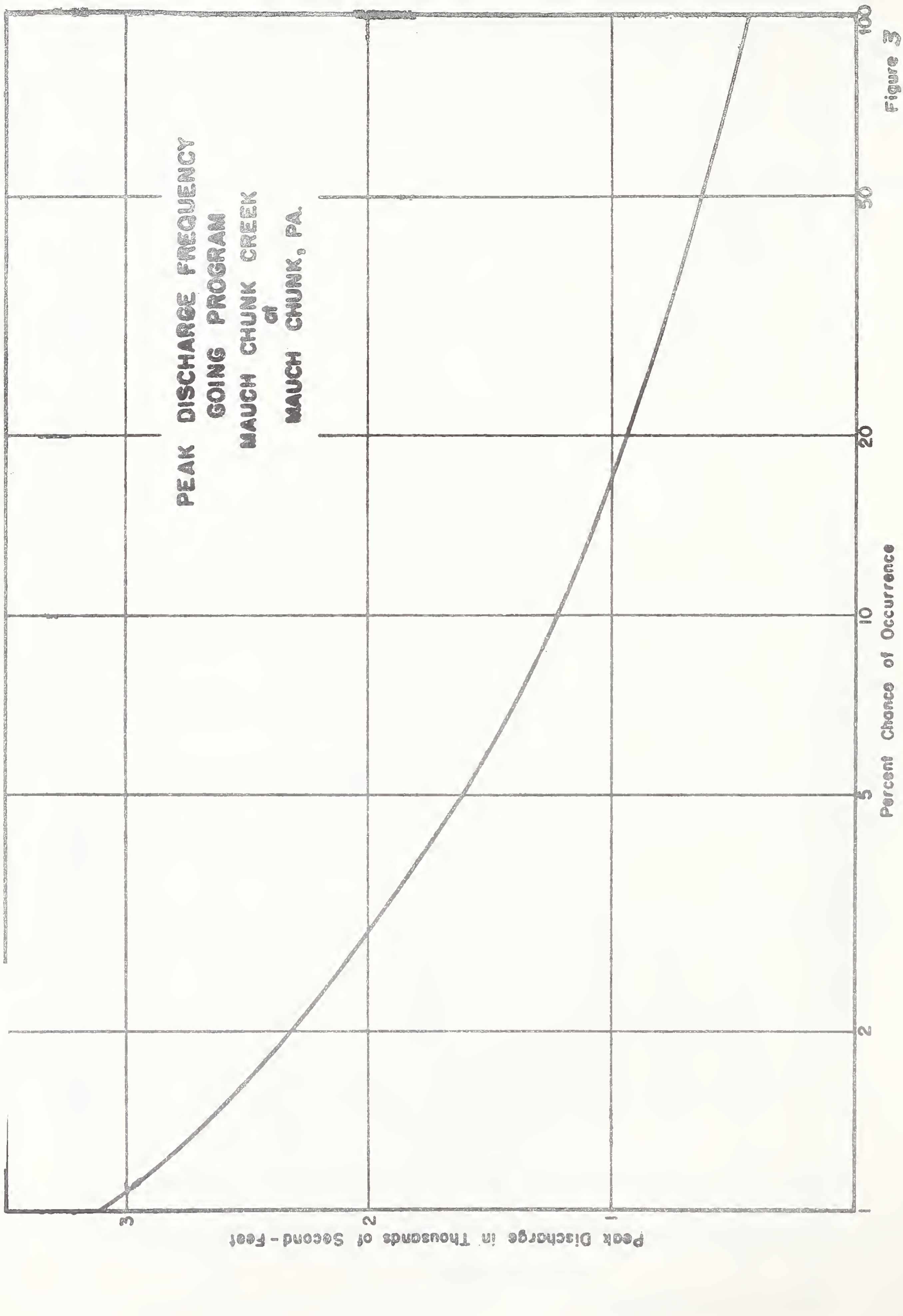

PEAK DISCHARGE FREQUENCY
GOING PROGRAM
MAUCH CHUNK CREEK
at
MAUCH CHUNK, PA.
Percent Chance of Occurrence
1
2
5
10
20
50
100
Peak Discharge in Thousands of Second-Feet
1
2
3

Figure 3

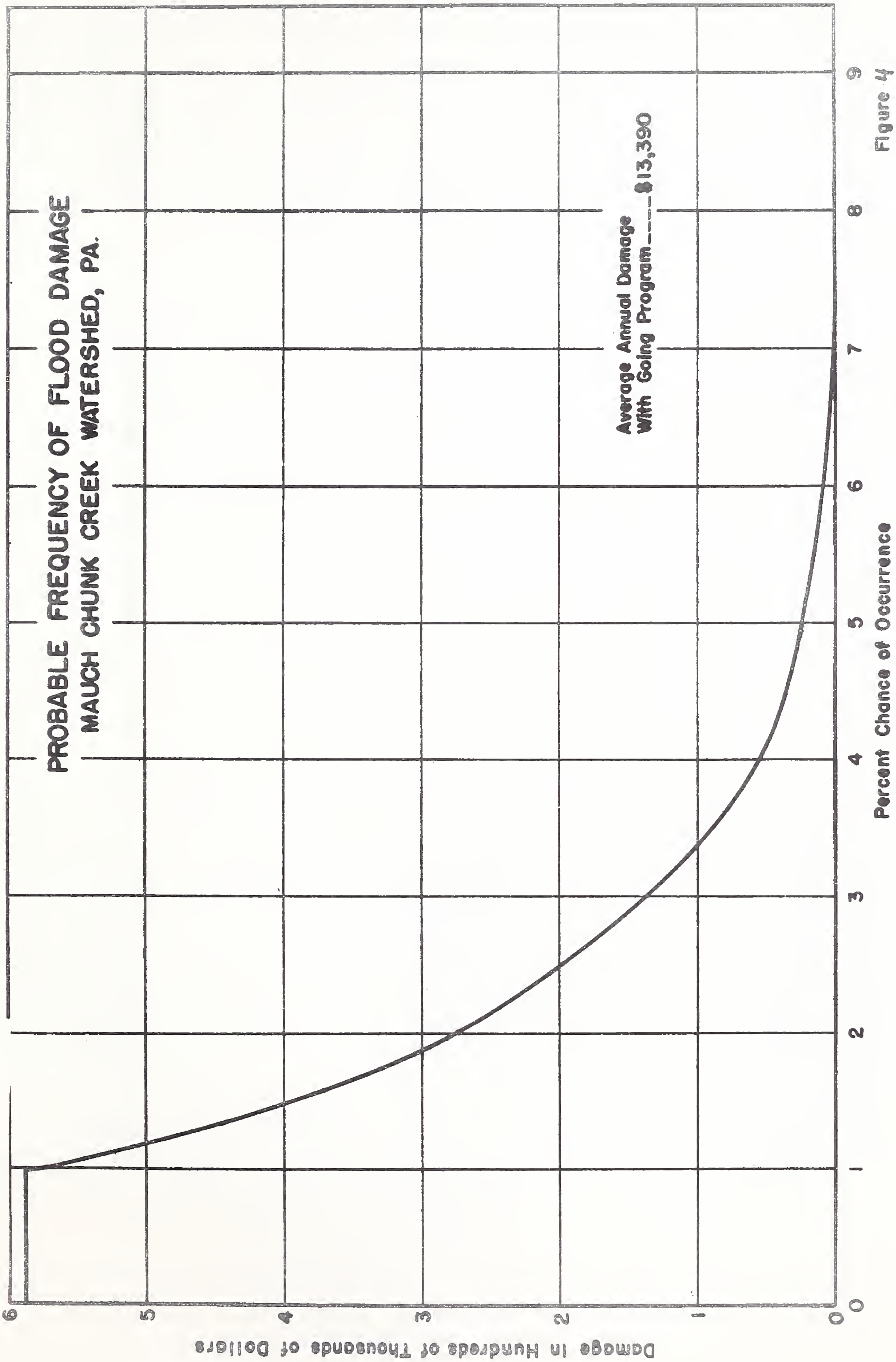

PROBABLE FREQUENCY OF FLOOD DAMAGE
MAUCH CHUNK CREEK WATERSHED, PA.
Average Annual Damage
With Going Program $13,390
Damage in Hundreds of Thousands of Dollars
0
1
2
3
4
5
6
Percent Chance of Occurrence
0
1
2
3
4
5
6
7
8
9

Figure 4

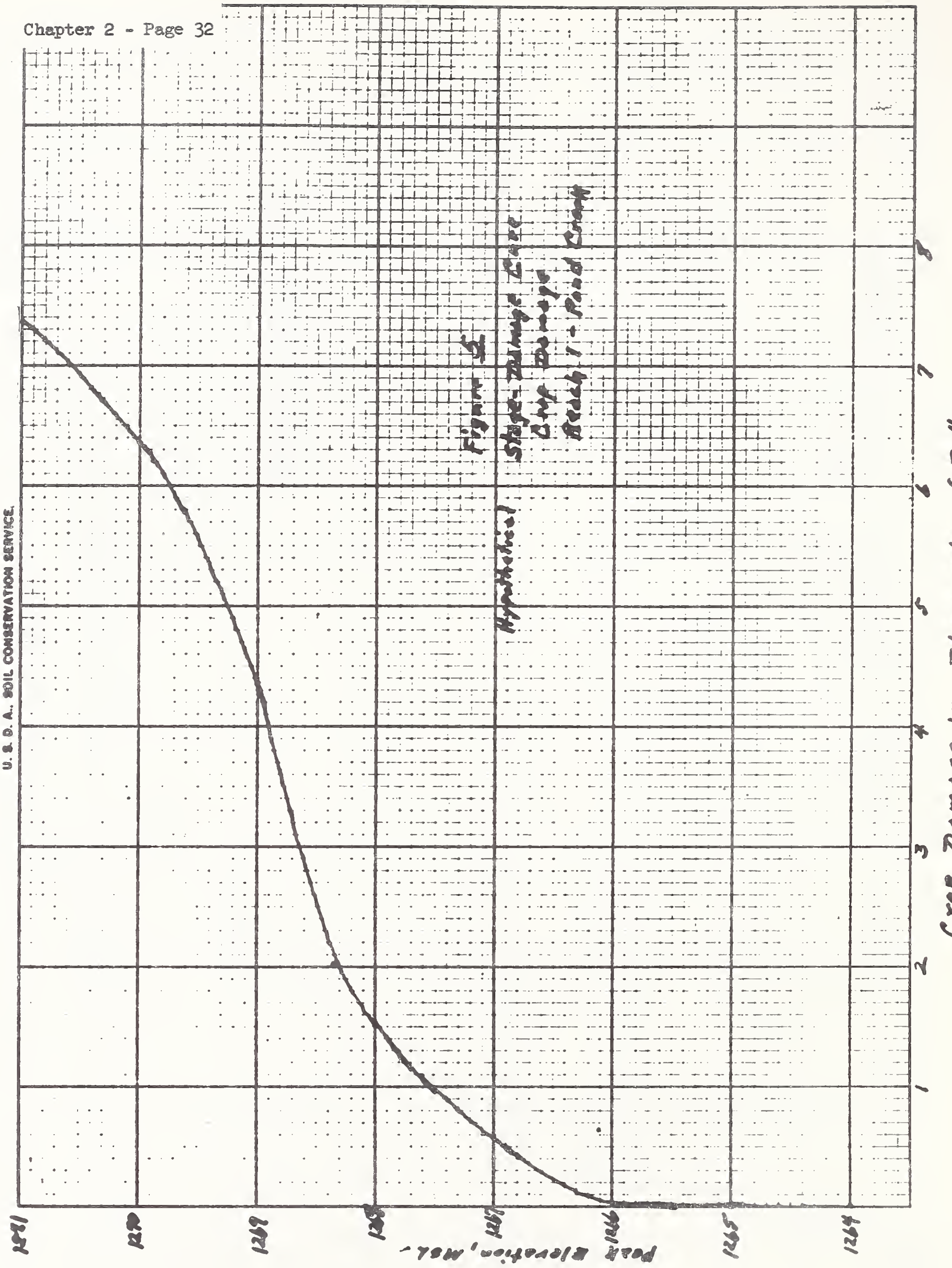


Figure 5
Stage-Damage Curve
Crop Damage
Reach 1 - Pond Creek
(Hypothetical)
Crop Damage in Thousands of Dollars
1
2
3
4
5
6
7
8
Peak Elevation, MSL
1271
1270
1269
1268
1267
1266
1265
1264

CHAPTER 3

APPRAISAL OF SEDIMENT AND EROSION DAMAGE

I. EVALUATION OF EROSION AND SEDIMENT DAMAGE TO AGRICULTURAL LAND

These damages reduce the productive capacity of land and may cause a change to less profitable use. The evaluation of damage should reflect the extent to which these adverse effects reduce net income.[1/] The evaluation should be based on productivity, land use, and net income under present conditions. Recovery of productivity and income due to natural processes or normal cultivation practices (without the program) should be taken into account.

All damage values should be converted to average annual values. Where discounting is necessary, the interest rate used should reflect the interests concerned (Federal; non-Federal, public and private). Average annual damage values should be calculated for each reach or significant subdivision of the watershed to permit benefit appraisal and program analysis.

A. Flood Plain Erosion and Sediment Damage Evaluation Methods (Agricultural Land).

1. The method used in evaluating these damages is based on the following:

a. Primarily, damage is a function of frequency of occurrence of floods varying in magnitude, duration and severity; secondly, a function of susceptibility of land to damage; and thirdly, sediment characteristics of the flow.

b. Benefits creditable to remedial measures are dependent upon the extent of modification of frequency of flooding, susceptibility of land to damage, and sediment characteristics of the flow. (Susceptibility of land to damage pertains to natural soil characteristics as well as protection afforded by vegetation or mechanical control.)

c. Where the program modifies the frequency of flooding and, in addition, modifies sediment characteristics of the flow, the effect on frequency of flooding should be measured first. Damages (or benefits) with the program, so determined, should then be adjusted to take into account changes in sediment characteristics of the flow brought about by control of sediment at its source by measures installed on the flood plain, stream channels and banks, and upland.

2. Damage evaluation.

a. The following information should be obtained for selected floods by interviewing farmers and by field inspection by technicians

1/ Gross value of production less crop production costs (growing, harvesting storing and marketing costs).

(economists and geologists). Whenever possible, technicians should be accompanied by farmers during field investigations in order that information can be obtained on specific areas of damage. The information indicated below should be obtained on all damaged areas within the sample for the floods selected for study.

(1) Acres damaged by selected floods.

(2) Percent of damage and income of land year after flood.

(3) Maximum recovery expected by selected floods.

(4) Time required to reach maximum recovery.

b. Net income values used should represent the difference in gross value of production less crop production costs (growing, harvesting, storing and marketing costs).

c. Calculation of damage by specific floods is demonstrated below. It is assumed that the above information is at hand for specific floods. Frequency and discharge of floods for which damages are calculated are indicated:

1954 Flood: Frequency 50%; Discharge 130 cfs.

Income of land just prior to damage by this flood	$19.95
Maximum recovery and income at maximum recovery-100%	19.95
Damage and income year after this flood-10%	15.82
Recovery time	4 years
Area damaged by this flood	1 acre
Damage calculation:	

$$\frac{\$19.95 - \$15.82}{4} \times \$9.25^{1/} \qquad \$10/\text{acre}$$

(Damaged) 1 acre

(Damage 1954 flood) $10

1948 Flood: Frequency 20%; Discharge 170 cfs.

Income of land just prior to damage by this flood	$19.95
Maximum recovery and income at maximum recovery-97%	18.71
Damage and income year after this flood-15%	13.76
Recovery time	7 years
Area damaged by this flood	2 acres

1/ PV decreasing annuity factor, 4 years @ 4%

Damage calculations:

$\$19.95 - \$18.71 \times 25$ 2/	\$31
$\frac{\$18.71 - \$13.76}{7} \times \$24.95$ 3/	18
	\$49/acre
(Damaged)	2 acres
(Damage 1948 flood)	\$98

<u>1946 Flood: Frequency 2%; Discharge 260 cfs; Damage \$770</u>

<u>1950 Flood: Frequency 1%; Discharge 290 cfs; Damage \$2,470</u>

Summary:

Flood	Frequency	Discharge	Damage Sample	Damage Reach
1954	50%	130	\$ 10	\$ 20
1948	20%	170	98	196
1946	2%	260	770	1,450
1950	1%	290	2,470	4,940

Damage for selected floods may also be evaluated by estimating the cost of repairing damage. However, in those instances where repair of flood plain damage after each flood is not the prevailing practice, estimates of cost of repair should be checked with estimates of damage determined by use of the above method and, whichever method gives the lowest damage figure, should be used in calculating average annual damage.

d. <u>Calculation of average annual damage</u>:

(1) Damages as related to frequency of flooding.

The use of the above damage data for selected floods in determining annual damage with and without the program requires the use of discharge-frequency curves representing conditions without the program and conditions as modified by the program. The damage-frequency curve for damage without the program can be plotted direct from the applicable discharge-frequency curve. But, preparation of a discharge-damage curve is needed to plot the damage-frequency curve for conditions with the program.

2/ PV annuity factor, perpetuity @ 4%
3/ PV decreasing annuity factor, 7 years @ 4%

The discharge-damage curve can be plotted by using damage by specific floods and discharges associated therewith. These data are presented in the above summary table. Damage-frequency curves with and without the program should be plotted on the same chart. The area below each curve represents the average annual damage for each condition; i.e., with and without the program. The area between the two curves represents the average annual benefit.

Based on assumed discharge-frequency curves with and without the program, from the data shown in the above "Summary" a discharge-damage curve can be prepared as well as damage-frequency curves (with and without program) by plotting the following points:

Frequency (%)	Without Program Discharge 1/ (cfs)	Damage 2/ ($)	With Program Discharge 3/ (cfs)	Damage 4/ ($)
50	130	20	110	10
20	170	196	140	100
2	260	1,540	220	900
1	290	4,940	260	1,540

(2) Damages with the program as effected by changes in control of sediment at its source.

The control of sediment at its source, whether upland stream channels and banks, or flood plain, by either vegetative or mechanical measures, may result in damage reduction in addition to that obtained by reducing the frequency of flood. This damage reduction may be taken into account by applying the percentage of reduction in source of sediment to the damage remaining after deducting effects of reduction in frequency of flooding.

(3) Damages with the program as affected by reduction in susceptibility of land to damage.

Where streambank erosion control measures are installed to attain control over and above that obtained by reduction in frequency of flooding, the effect of the measures in further reducing streambank erosion should be taken into account in determining the damage with the program and the benefit creditable to remedial measures.

1/ From discharge-frequency curve without program.
2/ From damages calculated for selected floods; i.e., 1954, 1948, 1946, 1950 floods related to frequencies indicated.
3/ From discharge-frequency curve with program.
4/ From discharge-damage curve (discharge-damage curve prepared by plotting data under "discharge"and "damage" without program)

3. An example of an alternate method of evaluating different kinds of agricultural land damage by erosion and sediment is presented in Appendix B. The method is based on the supposition that productivity will continue to decrease at about the rate that has prevailed over the period of cultivation, or other applicable period.

B. Upland Gully and Sheet Erosion Damage (Agricultural Land)

1. Gully erosion evaluation.

The evaluation is based on the following general factors:

a. The difference in use and net income on damaged land, and undamaged land subject to gullying.

b. The rate at which land is expected to be converted to lower income producing use due to field dissection.

Field observations will indicate the difference in use of gullied land, the use of land subject to gullying, the total area damaged and the total area subject to damage. The rate at which land is expected to be converted to lower income uses may be calculated by dividing the acreage on which gullying has caused a change in land use by the period over which this damage has occurred. The maximum period over which this rate can occur will be limited by the remaining area subject to damage. The net income value used in the evaluation may be computed as the gross value of crop production less production costs (growing, harvesting, storing, marketing costs). Sample calculation follows:

(1) Observed area on which gullying has caused a change in land use.		400 acres
(2) Period over which gullying has occurred		50 years
(3) Annual rate of conversion to lower income use	$\frac{400}{50}$	8 acres
(4) Area subject to future changed land use because of gullying		320 acres
(5) Maximum period over which damage can occur	$\frac{320}{8}$	40 years

(6) Difference in net income on gullied land and on land subject to gullying:

Ungullied land		$20
Gullied land		4
(pasture	$5 x .80 = $4)	
(gullies & idle	0 x .20 = 0)	
		$16 per acre

(7) Average annual damage: $16 x 8 acres x 19.79277 = $2,533

Discount factor: 19.79277 PV of 1, 40 years, 4% interest

2. Sheet erosion evaluation methods.

Experimental data indicate that sheet erosion damages the productivity capacity of the soil more or less permanently. Future yields on eroding fields may not decline in actuality because of the offsetting effects of improved fertility practices, however, yields will be less than they would have been had erosion not occurred.

The acreage upon which erosion damage is calculated should comprise only that acreage upon which the erosion exceeds the "allowable loss". Usually this will exclude land in permanent pasture, woods and other protective vegetative covers and cropland protected by conservation practices. The acreage should also exclude non-eroding land and land upon which erosion does not permanently impair productive capacity.

The evaluation should take into account the erosion that can be sustained without causing a reduction in the productive capacity of the soil. The amount that can be sustained is designated here as "allowable loss". (Sheet erosion control programs are usually geared to reducing soil losses at least to the "allowable loss".) The rate at which yields or productive capacity may be expected to decrease may be calculated as follows:

Erosion conditions under present land use:

	Corn 25%	Grain 25%	Hay 50%	Average	
	(t/ac)	(t/ac)	(t/ac)	(t/ac)	(ac/in) 1/
Gross annual soil removal	18	10	4	9	.06
"Allowable loss"	-3	-3	-3	-3	.02
Loss affecting decline of productive capacity	15	7	1	6	.04

Experimental data indicate a relationship between surface soil depth and crop yields. The average decline per inch of soil removal may be calculated as follows:

Yield decline per inch of soil removed: Corn 16%, Grain 8%, Hay 2%
Present land use: Corn 25%, Grain 25%, Hay 50%
Average decline per inch of soil removal: 7%

The period over which present rate of loss should be extended may be keyed to the time required for land to move to a lower capability class. The calculation of average annual damage follows:

1/ 150 tons = 1 acre inch

Gross average annual soil removal	.06 acre inches
"Allowable loss"	.02 acre inches
Loss affecting decline in yield	.04 acre inches
Yield decline per inch of topsoil removal	7%
No. years for land to drop one capability class	25 years
Soil loss during 25-year period affecting yield decline: 25 x .04	1 acre inch
Productivity level (yield) and net income 25 years hence: 100 - 7 = 93	$17.00 per acre

Rate of income loss:

Present income	(productivity level = 100)	$19.95
25 years hence	(productivity level = 93)	17.00
		$ 2.95

$2.95 ÷ 25 years $ .118 per acre

Average annual damage without program:

.118 x 171.72608 = 20.26368
.118 x 25 x 25 x .37512 = 27.66510
47.92878 x .04 = $1.92 per acre

No. acres subject to damage	10,000 acres
Average annual damage: 10,000 x 1.92	$19,200

Discount factors:

25	PV of 1 per annum - perpetuity
171.72608	PV of increasing annuity - 25 years
.37512	PV of 1, 25 years hence

II. EVALUATION OF GULLY EROSION DAMAGE TO LAND IMPROVEMENTS

The progressive land destruction by gully erosion often damages non-agricultural property including highways and other structures as well as farm improvements and structures such as buildings, fences, roads, etc. Expenditures made for temporary or emergency measures for protection of structures from gully erosion should be included in the average annual damage figure. Expenditures primarily made for measures providing more or less permanent protection should not be included in the average annual damage. Where it is feasible to relocate buildings and structures, the damage without the program can be estimated by determining the cost of relocation, including any loss of income or services because of relocation. In the case of expected damage to the highways, the cost involved in repairing the initial damage to the highway, plus the initial bridging and future bridging costs during the time the gully enlarges to its maximum width and extent can be used as the basis for evaluating expected damage without a program. Where a significant period is expected to

elapse before relocation repair, or other expenditures brought about by gullying, appropriate discounting procedures should be employed.

Calculations of average annual damage expected without the program are shown below. (The damage figures represent the average annual equivalent values of expenditures that will not have to be made if stabilization measures are installed.)

A. Where Relocation of Property is Feasible.

Cost of relocation	$6,000
Years to point where gullying causes relocation	5
Average annual damage $6,000 x .82193 x .04	$ 197

Discount factor: .82193 PV of 1, 5 years, 4% interest

B. Where Gullying is Expected to Damage Highway.

Cost to repair highway and bridging costs	$20,000
Years to point where gullying causes expenditures	5
Average annual damage $20,000 x .88385 x .025	$ 442

Discount factor: .88385 PV of 1, 5 years at 2½% interest

III. EVALUATION OF STREAMBANK EROSION DAMAGE TO LAND IMPROVEMENTS

The progressive land destruction by streambank erosion often damages non-agricultural property, such as highways, bridges, culverts, streets, sewage facilities, business and residential values, etc., as well as farm improvements, including farm buildings, fences, roads, drainage facilities, etc. The threat of land destruction may depress the value of land suitable for residential, industrial and business use or for specialized intensive agricultural use, or it may completely prevent residential, industrial, or business expansion and development in the most logical and advantageous direction. The benefits from the control of these latter adverse effects should be evaluated as enhancement of property values rather than streambank erosion damage. Expenditures made for temporary or emergency measures for protection from streambank erosion should be converted to average annual values and treated as streambank erosion damage. Expenditures previously made for measures providing more or less permanent protection should be excluded from the damage value.

The evaluation should be based on the most probable course of action. In certain instances streambank erosion can be expected to progress to the point that specific structures, businesses or properties,

will be damaged or destroyed. Where it is not feasible to relocate a structure or where property is irreplacable, the damage can be considered as equal to the value of the structure less salvage value. Where relocation of the structure is feasible, the damage can be estimated by determining the cost of relocation, including any loss of income or business because of location.

The period of time before streambank erosion is expected to progress to the point of damaging or destroying the structure, or causing replacement or relocation, should be taken into account in computing the average annual damage by applying appropriate discounting procedures. Calculations of the average annual damage expected without the program are shown below. (The values represent average annual equivalent values of expenditures or losses that will not be experienced if streambank erosion control measures are installed.)

A. Where it is Not Feasible to Relocate a Structure or Business.

Value of structure, business and business property, less salvage value	$100,000
Years to point where erosion destroys structures, business or property	5
Average annual damage $100,000 x .82193 x .04	$ 3,288

Discount factor: .82193 PV of 1, 5 years, 4% interest

B. Where Relocation of Business or Property is Feasible.

Cost of relocating structure, residence, etc.	$ 5,000
Years to point where erosion causes relocation	7
Average annual damage $5,000 x .75992 x .04	$ 152

Discount factor .75992 PV of 1, 7 years, 4% interest

IV. EVALUATION OF SEDIMENT DAMAGE TO RAILROADS AND HIGHWAYS

In many instances local governments and railroad companies spend considerable sums for the removal of sediment to maintain transportation services and to protect investments in roads and structures. Most frequently the expenditures are made to remove sediment from road surfaces, road ditches, culvert and bridge openings, and from those drainageways served by bridges and culverts. The removal of sediment from bridges and culverts and adjacent drainageways is usually done to protect structures, including road surfaces and roadbeds, from overflow or other types of floodwater damage. The extent of such expenditures may be treated as representing sediment damage to highways and railroads. Occasionally sediment is not removed in sufficient quantities to maintain services or prevent damage. In these cases, either the cost of removing sediment

necessary to maintain services and prevent damage may be estimated or the damage caused to rights-of-way and structures, and value of services lost because of sediment deposition, may be estimated and used in evaluating the average annual damage expected without a program.

In most instances, the average annual damage can be calculated by obtaining the sum of expenditures for sediment removal over a representative period of years and dividing by the number of years of record. The expenditures should be itemized in such a manner as to permit an evaluation of the effects of the program; i.e., the costs for removing sediment from culverts and bridges and drainageways adjacent thereto, should be separated from the cost of removing sediment from road ditches or for removing sediment from road surfaces. As to road ditches, often a major source of the material removed is from the road surface and its replacement is a part of normal road maintenance and not associated with sediment damage. In such cases, the additional expense occasioned for the removal of sediment originating from erosion at sources other than road surfaces should be estimated and used in the damage evaluation. It is important to obtain from the informant an estimate as to what, in his opinion and experience, is the source of sediment being removed. With this information, along with that obtained from investigation by physical scientists with respect to source of sediment, it will be possible to estimate the benefits of the program in reducing sediment damage either through erosion-control measures, water-flow measures, or measures for sediment entrapment.

V. EVALUATION OF SEDIMENT DAMAGE TO MUNICIPAL AND INDUSTRIAL WATER SUPPLIES

The sediment content of water used for municipal and industrial purposes may result either in expenditures for treating water so that it is suitable for these purposes, or in damage to machinery or other water facilities or impairment of the quality of the manufactured product. (Sediment damage evaluation considered here is not concerned with loss of reservoir storage capacity.) In some instances, these adverse effects may be factors influencing the location of water storage facilities or the location of industrial plants resulting in a more costly supply of water or less efficient production than would otherwise be the case. These costs are difficult to establish with a reasonably wide degree of acceptance, so unless firm bases for estimates are available, they should not be included in the damage evaluation.

The monetary evaluation of sediment damage usually can be made by obtaining the expenditures made by municipalities or industrial concerns for treatment of water to correct the damaging effects of sediment or by obtaining estimates of damage to machinery and the reduction in quality of product. In many instances, water is treated to correct the sediment content as well as other conditions affecting the use of water.

In such instances, only the additional treatment costs made necessary because of sediment should be used in evaluating sediment damage. In appraising the damage to machinery, expenditures for repairs and the reduced life of machinery can be used as the bases for estimating the average annual damage. Where the useful life of machinery or other water supply facilities are impaired, estimates of the value of machinery affected, and the expected life of the property with and without sediment damage should be obtained from the owners concerned. These will provide the information necessary to express the damage as the difference in the amounts of sinking fund with and without damage. Interest rates used in calculating sinking funds should reflect the interest paid by the property holders affected. Losses due to reduction in quality of product can be estimated by obtaining from the manufacturer the increase in market price that could be realized for the product without the adverse effects of the sediment content of water. Any additional costs of processing, distributing, and marketing the higher quality product should be deducted from the increase in value of the product. Sample calculations of average annual damage are presented below.

Improved quality of product:

Gross value of product without sediment damage	$500,000
Gross value of product with sediment damage	450,000
Difference	$ 50,000
Additional cost of processing, distributing, and marketing the higher quality product	$ 15,000
Average annual damage (50,000 - 15,000)	35,000

Water Treatment Costs:

Total average annual expenditures	$ 3,000
Expenditures because of other than sediment content of water	2,500
Treatment costs attributable to sediment	$ 500

Machinery repair costs:

Expenditures for repairs due to sediment (ave. annual)	$ 4,000

Reduction in useful life of machinery because of sediment:

Useful life without damage	15 years
Useful life with damage	12 years
Sinking fund needed for replacement with damage	$ 5,989.50
Sinking fund needed for replacement without damage	4,494.60
Cost of replacing machinery	100,000.00
Salvage value of machinery	10,000.00
Difference	$ 90,000.00

Calculation of average annual damage:

Sinking fund with damage	90,000 (.06655 - .04)	$5,989.50
Sinking fund without damage	90,000 (.04994 - .04)	4,494.60
Difference		$1,494.90

Discount factors - 4% interest:

.06655 Sinking Fund, 12 years
.04994 - Sinking Fund, 15 years

VI. EVALUATION OF SEDIMENT DAMAGE TO DRAINAGE AND IRRIGATION FACILITIES

Sediment deposited in open drainage ditches impairs drainage and causes a gradual reduction in crop yields and income. Usually ditches are cleaned out periodically. Remedial measures for sediment control will lengthen the period between cleanouts. For practical purposes, damage with and without the program can be calculated by applying sinking fund factors to the cost of periodic cleanout as indicated below:

Damage without program:

Periodic cleanout	20 years
Cost of each cleanout	$20,000
Sinking fund factor (20 yrs @ 4%)	.03358
Average annual damage (20,000 x .03358)	$ 672

Damage with program:

Periodic cleanout	40 years
Cost of each cleanout	$20,000
Sinking fund factor (40 yrs @ 4%)	.01052
Average annual damage (20,000 x .01052)	$ 210

Ditch cleanout costs often include expenditures other than for sediment removal. In such cases, appropriate adjustments should be made to eliminate costs other than those related to sediment removal.

VII. EVALUATION OF RESERVOIR SEDIMENTATION

A. Evaluation Methods.

Damages to reservoirs (and benefits from programs) may be estimated by four different methods, depending upon (1) the amount of information that is available or that can be obtained within the limitations of budget and other resources (2) the number of reservoirs to be evaluated and (3) the importance of the monetary benefits accruing from reduced rates of reservoir sedimentation in relation to the overall

economic justification of a flood-control program. These four methods are referred to as (1) straight-line (2) sinking fund (3) sinking fund plus service loss and (4) cost of sediment removal.

1. Straight-line.

The average annual damage is estimated as the product of the average annual rate of sedimentation in acre feet and the original cost of storage per acre foot adjusted to prices prevailing at the time of the survey. The average annual benefit is the difference between the average annual damages with and without the recommended program.

Example:

a. Adjusted cost per acre foot of total storage	$60.00
b. Volume of sediment deposited annually without the recommended program	335 acre feet
c. Volume of sediment deposited annually with the recommended program	168 acre feet
d. Average annual damage without program (335 x 60)	$20,100
e. Average annual damage with program (168 x 60)	10,080
f. Average annual benefit (d - e)	$10,020

2. Sinking fund.

The average annual damage is estimated as the annual payment into a sinking fund which, at a given rate of interest ($2\frac{1}{2}$% or 4%, as the case may be) will accumulate to an amount sufficient to replace the volume of storage displaced by sediment at the time when the useful life of a reservoir is terminated. The average annual benefit is the difference between the average annual damages with and without the recommended program.

Example:

a. Useful life of reservoir without program	50 years
b. Useful life of reservoir with program	100 years
c. Replacement cost of capacity lost	$1,000,000
d. Average annual damage without the recommended program (1,000,000 x .0065502[1])	6,550
e. Average annual damage with the recommended program (1,000,000 x .0008080[2])	808
f. Average annual benefit (d - e)	$ 5,742

1/ Sinking fund factor for 50 years @ 4% interest
2/ Sinking fund factor for 100 years @ 4% interest

3. Sinking fund plus service loss.

The average annual damage is estimated as the annual payment into a sinking fund which, at a given rate of interest, will accumulate to an amount sufficient to replace the volume of storage displaced by sediment at the time when the useful life of a reservoir is terminated, plus the average annual equivalent value of the present worth of all service losses that occur prior to replacement of the reservoir. The average annual benefit is the difference between the average annual damages with and without the recommended program.

Example:

a.	Useful life of reservoir without program	50 years
b.	Useful life of reservoir with program	100 years
c.	Replacement cost of capacity lost	$1,000,000
d.	Annual payment into sinking fund for replacement in 50 years	6,550
e.	Annual payment into sinking fund for replacement in 100 years	808
f.	Annual increment of service loss without program	2,000
g.	Annual increment of service loss with program	1,000
h.	Present worth of service loss over 50 years without program (2,000 x 382.64603[1/])	765,292
i.	Present worth of service loss over 100 years with program (1,000 x 587.62985[2/])	587,630
j.	Average annual equivalent value of service loss without program (765,292 x .04655[3/])	35,624
k.	Average annual equivalent value of service loss with program (587,630 x .04081[4/])	23,981
l.	Average annual damage without program (d + j)	42,174
m.	Average annual damage with program (e + k)	24,789
n.	Average annual benefit (l - m)	$ 17,385

This example has been simplified for purposes of illustration. Thus, it has been assumed that service losses would begin immediately and would increase uniformly until an assumed date of replacement. In actual practice, however, it will be necessary to determine the time at which service losses will begin, how and at what rate such losses will occur, and when the lost reservoir capacity will be replaced. In some instances, it may be determined that replacement is not feasible and that the project must be abandoned when the reservoir no longer can supply the required services. Here, the additional values lost because of abandonment must be taken into account.

1/ PV of increasing annuity by 1 per year for 50 years @ 4%
2/ PV of an increasing annuity by 1 per year for 100 years @ 4%
3/ Amortization factor, 50 years, 4% interest
4/ Amortization factor, 100 years, 4% interest

4. Cost of sediment removal.

The average annual damage is estimated as the product of the number of cubic yards to be removed annually and the cost per cubic yard for removal. The average annual benefit is the difference between the average annual damages with and without the recommended program.

Example:

a. Volume of sediment to be removed annually without program	540,355 cu. yds.
b. Volume of sediment to be removed annually with program	270,984 cu. yds.
c. Cost of removal per cubic yard	$ .50
d. Average annual damage without program	270,178
e. Average annual damage with program	135,492
f. Average annual benefit (d - e)	$134,686

For any method of evaluation used, it is necessary that values be on a common time basis. All values should first be calculated on the basis of current prices for presentation in the report and then converted to the price levels recommended by the former Bureau of Agricultural Economics for computing the benefit-cost ratio.

B. Conditions Governing Use of Methods.

The time and cost limitations of work plan preparation surveys require that estimates of reservoir sedimentation damages and benefits be developed by the use of methods which fall within the scope of these limitations. With this in mind, the following criteria are herewith established as a guide to the choice of methods to be applied.

1. Straight-line.

a. Where a large number of existing and authorized reservoirs must be evaluated and facilities are not available to make a detailed analysis of each reservoir. This will not preclude detailed analysis of individual reservoirs if their importance warrants such treatment.

b. Where the available information clearly indicates that service losses will occur, but sufficient information to permit the application of the sinking fund plus service loss method cannot be obtained within the limitations of budget and other resources.

2. Sinking fund.

Where the obtainable information clearly indicates that the reservoir will be replaced prior to any significant loss of services.

3. Sinking fund plus service loss.

Where, in the judgment of the planning party, sufficient data exist or are obtainable within the limitations of budget and other resources to permit making reasonable estimates of the individual determinations required by this method.

4. Cost of sediment removal.

Where sufficient information has been obtained to indicate that reservoir storage will be maintained by the removal of sediment.

If, after applying the appropriate method, the results reflect such a small part of the values involved as to distort the presentation, it may be desirable to omit the monetary evaluation and present a detailed qualitative description of the benefits that will accrue as a result of reduced rates of sedimentation. In any event, all values omitted or not adequately taken into account in the monetary evaluation should be described in appropriate terms, and the inadequacies of the method used to determine the monetary values should be set forth.

CHAPTER 4

EVALUATION OF RESTORATION OF FORMER PRODUCTIVITY AND CHANGED USE OF FLOOD PLAIN LAND

I. GENERAL

Many times areas of formerly improved flood plain land will be found that were once in cultivation or pasture, but are now abandoned or in low income producing uses because of adverse effects of flooding. Installation of flood damage prevention measures may reduce the flood hazard sufficiently to induce farmers to restore the flood plain to a use consistent with its former productivity. The difference in net income between that which is now being received and that which is expected to prevail under the restored condition, is a "restoration of former productivity" benefit (Class 1). This benefit should not be confused with that obtained from changing the use of flood plain land that has never been in cultivation, but which may be put into cultivation as a result of the project. For example, if land that has always been in woods, pasture or wild land, etc., is converted to cropland as a result of the project, the benefits resulting would be classed as "changed land use" benefits (Class 2).

Identification of the areas upon which these two classes of benefits may accrue is basic to the evaluation. The extent of the area subject to benefit will usually be governed by the following:

A. Degree of protection afforded by measures.

B. Degree of protection necessary to induce farmers to restore land to its former use or to change land use.

C. Factors other than flooding:

1. Capability of the land.

2. Width of flood plain.

3. Type of farming.

4. Willingness, intentions and financial ability of farmers to make the necessary conversions in land use, etc.

5. In order to claim "restoration of productivity" as a benefit positive assurance should be had that (1) the land was formerly used for crop or pasture production, and (2) that flooding is the direct cause of the reduced productivity.

The above limitations are of primary concern in identifying the area. Where these limitations prevail it may not be practical to claim this

benefit in determining economic justification. Therefore, the extent and importance of the above factors should be investigated prior to further study in connection with these evaluations.

The benefit calculation for both restoration of productivity and changed land use should be based on the effect of the measures on reducing the frequency of flooding. Determination of the area subject to benefit will involve estimating the area flooded at each significant frequency interval, with and without the measures. These data can be obtained from cross-sections of the flood plain showing present land use by elevation; discharge-frequency curves, present, and as modified by the program, and stage-discharge curves. As indicated, present land use at various flood-frequency intervals can be obtained by relating discharge-frequency and stage-discharge curves to cross sections. The relationship of frequency of flooding to land use will be indicated by the use to which land is now put under various conditions of flooding. That is, if land flooded 1 year in 3 is used for pasture at present, it will likely be used for pasture in the future if flooded at the same frequency. This may be used as the basis for estimating expected future land use and damageable values with flood protection.

For both of these items, the monetary benefits should be measured as the difference in net returns with and without the program. These calculations should take into account flood damages with and without the program and cost of conditioning or developing the land for a change in land use. Calculation of flood damages with the project under both will involve a complete average annual damage evaluation using discharge as modified. Because of the changed land use, a new stage-damage curve should be prepared.

It should be noted that the increase in income is corrected for the flood damage done to the higher value production from the remaining floods and for associated development costs. See sample calculations below.

In those instances where there is a lag in attaining the maximum benefit possible, appropriate discounting procedures should be used. For example, some farmers may want to wait and see how effective the program is before changing land use.

The following sample calculations illustrate a method for determining each of the above described types of benefits.

II. RESTORATION OF FORMER PRODUCTIVITY BENEFIT

Frequency of Flooding 1/ (% time)	Present Acres	Present Land Use	Future With Program Acres	Future With Program Land Use
33	70	Pasture	50	Pasture
20	80	COH 2/	60	COH
10	90	CCCOH	60	CCCOH
5	100	CCCOH	60	CCCOH
2	115	CCCOH	60	CCCOH
1	120	CCCOH	120	CCCOH

Frequency of Flooding 1/ (% time)	Present Acres	Present Land Use	Present Net Returns 3/	Future With Program Acres	Future With Program Land Use	Future With Program Net Returns 3/
33	70	Pasture	$280	50	Pasture	$200
33-20	10	COH	54	10	COH	54
>20	40	CCCOH	656	60	CCCOH	984
Total	120		$990	120		$1,238

Increased net return	$1,238 - $990	$ 248
Less added flood damage		25
Less development cost (associated cost)		30
Restoration of Former Productivity Benefit		$ 193

1/ Crop season basis

2/ Crop distribution: C=corn, O=oats, H=hay

3/ Net income per acre:

COH: C=$10, O=$1, H=$5; Average $5.36

CCCOH: C=$20, O=$7, H=$15; Average $16.40

III. CHANGED LAND USE BENEFIT

Frequency of Flooding 1/ (% time)	Present: Acres	Present: Land Use	Future With Program: Acres	Future With Program: Land Use
100	40	Unimproved 2/		
50	60	Unimproved 2/		
33			10	Pasture
20			30	COH
10			30	CCCOH
5			30	CCCOH
2			30	CCCOH
1			60	CCCOH

Frequency of Flooding 1/ (% time)	Present: Acres	Present: Land Use	Present: Net Returns 2/	Future With Program: Acres	Future With Program: Land Use	Future With Program: Net Returns 3/
50+	60	Unimproved	$18			
5-33				10	Pasture	$ 40
33-20				20	COH	107
>20				30	CCCOH	492
Total	60		$10	60		$639

Increased net return $639 - $18	$621
Less added damage	70
Less development cost (associated cost)	310
Changed land use benefit	$241

1/ Crop season basis

2/ Unimproved land. Woods, pasture, wild land, etc.

3/ Net income per acre: Unimproved land $ .30; Pasture $4.00

COH: C=$10, O=$1, H=$5; Average $5.36

CCCOH: C=$20, O=$7, H=$15; Average $16.40

CHAPTER 5

APPLICATION OF ECONOMIC ANALYSIS IN PROJECT FORMULATION

I. GENERAL

The economic objective of project formulation has been expressed in numerous ways. The essential idea expressed in these statements is that project measures should be designed and combined in such a way that net benefits are greater than any alternative design and combination of measures. Through proper planning and evaluation procedures, this objective may be approached even though its precise attainment may not be realized.

It is important, therefore, to approach each phase of the planning process with this economic objective clearly in mind. This objective can be fully realized only by the analysis of a reasonable number of possible alternatives. Basic appraisal data should be developed in so far as possible, in such a way as to facilitate this type of analysis.

In formulating projects under Public Law 566, it should also be understood that the wishes and desires of the local people, with respect to the cost, scope or scale of a project, must be considered at all times and the aim should be to design the project to produce maximum net benefits within the framework of these wishes and desires.

Maximum net benefits are not the scale of development which give the maximum benefit-cost ratio, nor is it the scale of development where the ratio is one to one. It lies somewhere between these two points. It can be defined as the point where the benefits added by the last increment of extension of scope are equal to the cost of adding that increment of scope to the development. Expressed in another way, net benefits are at a maximum where the incremental benefit just equals the incremental costs.[1]

In many cases, the cost of making a detailed and precise appraisal of the types suggested in this chapter cannot be justified in terms of the resulting savings. Rather than excluding the analysis, however, it is suggested that it be carried out on the basis of the best estimates which can be provided within the limitation of time and funds. Usually, judgments based on brief analysis can set reasonable limits, beyond which we should not go, in formulating a project within violating the principles of sound economics. The degree to which the required economic data are refined should be determined on the basis of prospective economies that would likely result. The application of this principle would permit greater refinement for expensive measures and projects than for the less expensive.

Two other important factors may modify the scope or scale of a project in such a way that full maximization of benefits would not be possible. These are (1) where policy considerations dictate a definite degree of flood protection, say for all floods of a 25-year frequency or less, and (2) where a high degree of protection is necessary because of the possibility of loss of life in the absence of a high level of protection.

1/ See Chapter 2, "Proposed Practices for Economic Analysis of River Basin Projects," by the Subcommittee on Benefits and Costs, May 1950.

Section 2 of the Handbook states, "The Service will emphasize proper land use and treatment as the most fundamental requirement of a successful watershed project. A high degree of application of needed land-treatment measures will be required prior to furnishing financial assistance in installation of structures." Therefore, in considering structural measures for flood damage reduction, the expected reductions to be effected by the land-treatment measures to be installed, should be subtracted from the total flood damages before structural measures for flood damage reduction and other purposes are considered. Account should be taken, however, of any lag in effectiveness of these measures.

In project formulation, it will be the usual practice to plan those land-treatment measures that are required by the Act and Administrative Regulations, that will be expected to be installed within a 5 or 10-year period.

This chapter deals with some suggested procedures for handling the major types of situations to be encountered in planning watershed projects. The types of situations covered are: (1) establishing the scale of a single-purpose independent measure, (2) establishing the economic justification and scale of a multiple-purpose independent structure, (3) establishing the economic scale of a single-purpose structure with multiple benefits and (4) appraisal of alternative types of measures for a single purpose.

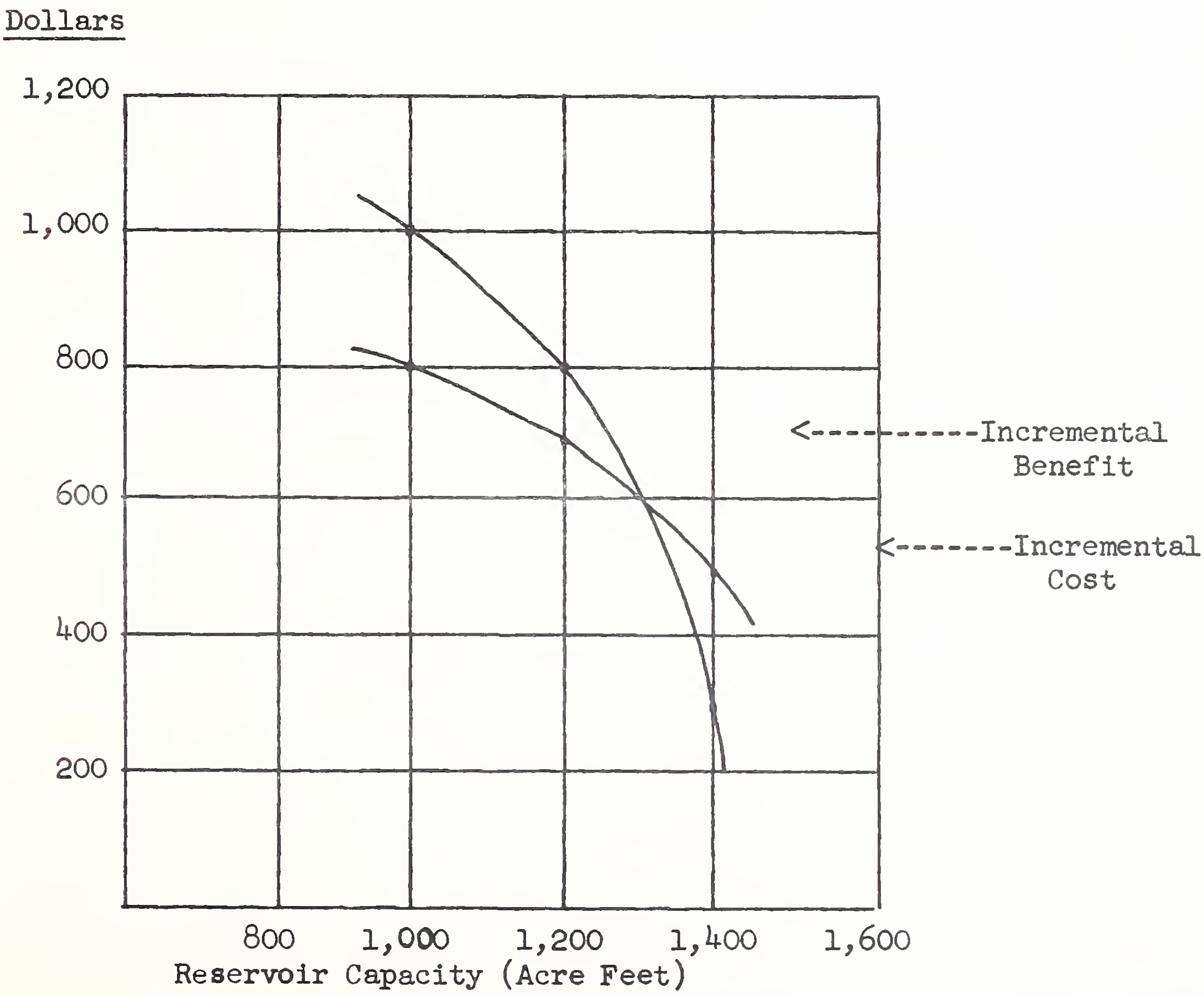
(1) <u>Single-purpose independent measures</u>. For the purpose of illustration, it is assumed that the problem is one of determining the <u>economic scale</u> of a floodwater-retarding reservoir. If the scale of the structure is properly determined, the saving from reducing its size would be less than the loss of benefits. Likewise, the cost of increasing its size would be greater than the resulting increase in benefits.

The first step in the analysis is to choose a specific design for the given flood control structure and appraise it in terms of costs and benefits. The second step is to add another increment of capacity to the original design and to appraise the benefits and costs of the modified structure. Assuming that the benefits from the additional increment of storage are greater than the additional cost, a second increment of control may be added and evaluated. This process can be continued until the last increment of control is no longer justified in terms of incremental costs and incremental benefits. When this point is reached, the incremental costs and incremental benefits are plotted graph paper. The point at which the resulting curves intersect will indicate the appropriate scale of the structure in question. The required data are illustrated in Table 1 and the relationships between costs and benefits are shown in Figure 1.

Table 1 - Total Annual Costs and Annual Benefits; and Incremental Cost and Incremental Benefit for Alternative Capacities for a Floodwater-Retarding Reservoir1/

Storage Capacity (Acre ft.)	Annual Costs: Total Costs (Dollars)	Annual Costs: Incremental Costs (Dollars)	Annual Benefits: Total Benefits (Dollars)	Annual Benefits: Incremental Benefits (Dollars)
800	4,000	---	6,000	---
1,000	4,800	800	7,000	1,000
1,200	5,500	700	7,800	800
1,400	6,000	500	8,100	300

Figure 1 - Relationship of Incremental Cost to Incremental Benefit for Different Storage Capacities for Floodwater-Retarding Structure1/



1/ Data are hypothetical

In the data assumed in Table 1, the floodwater-retarding structure can be increased in size from 800 acre-feet to 1,000 acre-feet for an additional cost of $800 annually. Likewise, the structure may be increased in size from 1,000 to 1,200 acre-feet for an additional annual cost of $700. An additional 200 acre-feet of storage in the assumed data can be added for an annual cost of $500. In the benefit data assumed, the first increase of 200 acre-feet capacity would provide an additional $1,000 benefit and the second increase of 200 acre-feet would provide benefits amounting to $800. By increasing the structure from 1,200 to 1,400 acre-feet, however, produces benefits amounting to only $300. These data, plotted in Figure 1, indicate that the reservoir capacity should be 1,300 acre-feet of storage in order to maximize net benefits. Either decreasing or increasing the capacity of the structure at this point would reduce net benefits creditable to the structure.

(2) Establishing the economic justification and scale of a multiple-purpose independent structure. In the illustration just cited, the problem was one of expanding the capacity of a structure until the annual cost of the last unit added was exactly the same as the additional benefit. For a multiple-purpose storage structure, the procedures are similar, but slightly more complex.

The first step is to select an initial increment or nucleus of the project before the scale of development can be expanded by adding increments as illustrated in (1) above. In a multiple-purpose structure any one of the purposes may be selected as the first increment for analysis. Also, this first increment need not necessarily be economically justified, but, as illustrated below, must be justified for inclusion in the project when considered as the last increment.

Purpose of Capacity	Increment	Capacity	Average Annual Benefit	Average Annual Cost	Net Benefit	Benefit-Cost Ratio
		(Ac/ft)	($)	($)	($)	
Flood Prev.	First	2,000	140,400	191,250	- 50,850	Unfavorable
Irrigation	Second	1,000	156,600	63,750	+ 92,850	Favorable
TOTAL		3,000	297,000	255,000	+ 42,000	Favorable
Irrigation	First	1,000	156,600	159,375	- 2,775	Unfavorable
Flood Prev.	Second	2,000	140,400	95,625	+ 44,775	Favorable
TOTAL		3,000	297,000	255,000	+ 42,000	Favorable

Unless the above requirements are met it would not be possible to say that each separable purpose justified the added costs of its inclusion in the project. The next step in the analysis would be to add successive increments of storage capacity for one or both purposes as described under item (1) above. This process can be continued until the last increment is no longer justified in terms of incremental costs and incremental benefits or a total storage capacity of 5,000 acres is reached.

(3) Establishing the economic scale of a single-purpose structure with multiple benefits. In the economic analysis of structures designed primarily for detention or storage of water, cases will be found where the same reservoir capacity serves dual uses, such as flood prevention, use of water in the sediment pool for stock water, irrigation, recreation or other purposes, and under certain hydrologic conditions, the temporary use of flood detention capacity for irrigation may be possible.

Where there is no increase in storage costs of providing any of the uses included, the benefits from all uses may be lumped and equated against all costs in the economic analysis. The scale of development, however, may be determined by using the same procedures as described in (1) above.

(4) Appraisal of alternative types of measures for meeting a single purpose. In formulating a project, alternative means of accomplishing a specific purpose are frequently available for consideration. In the economic analysis it will often become necessary to give consideration to one or more alternatives. For example, for flood prevention, the following measures might be physically feasible for a given area: channel improvement, floodwater-retarding structures, diking and floodway diversions. Each measure standing alone would first be analyzed so as to maximize its benefits as outlined in (1) above. Then in the analysis the following possibilities, among others, would be considered:

	Benefit	Cost	Net Benefit	Benefit-Cost-Ratio
1. Floodwater-retarding structure alone	$45,000	$20,000	$25,000	2.25 to 1
2. Channel improvement alone	15,000	10,000	5,000	1.50 to 1
3. Floodway diversions alone	2,500	5,000	--	.50 to 1
4. Diking alone	10,000	4,000	6,000	2.50 to 1
5. Retarding structures plus channel improvement:				
Retarding structures	45,000	20,000	25,000	
Channel improvement	11,000	10,000	1,000	
Sub-Total	56,000	30,000	26,000	1.87 to 1
6. Retarding structures plus diking:				
Retarding structures	45,000	20,000	25,000	
Diking	2,500	2,000	500	
Sub-Total	47,500	22,000	25,500	2.16 to 1

Analysis: All of the alternatives, when considered alone, show a favorable benefit-cost ratio except floodway diversions. Diking shows

the most favorable ratio; however, the maximum net benefit is not attained by this alternative. Retarding structures, plus channel improvement (alternative 5) show the greatest excess of benefits over costs and the overall benefit-cost ratio is favorable. Therefore, it would be the first choice for inclusion in the project. The second choice would be alternative 6, the third choice alternative 1, the fourth choice alternative 4, etc. Alternative number 4, however, is definitely uneconomic and therefore can be discarded as a choice for inclusion in the project.

II. ESTABLISHING COMBINATION OF SEPARABLE STRUCTURAL MEASURES TO OBTAIN MAXIMUM NET BENEFITS

In formulating projects consisting of several separable measures, economic analysis should include consideration of possible functional dependency between measures. For example, installation of two distinctly separable measures may add to the effectiveness of one or both of the measures. This relationship is shown and analyzed in the following example of streambank stabilization and a floodwater-retarding structure. For example, Table 1 shows the average annual flood and sediment benefits, by sources, that could accrue to land-treatment measures and to five different separable structural measures. Evaluation of structural measures in each case was made only after considering the effectiveness of land-treatment measures. It may be noted in Table 1, that all of the benefits provided by the floodwater-retarding structure, when considered as the only structural measure, occur through stabilizing those sources and reducing flood flows that could not be effected by either of the two types of streambank protection measures. Table 1 also indicates that "Sb-1", if applied alone, would provide complete stabilization of banks where it is installed, while "Sb-2" would provide only 50 percent control if applied by itself. By combining the floodwater-retarding structure and "Sb-2", the effectiveness of stabilizing eroding streambanks is increased from 50 to 80 percent without increasing the cost of either feature. If "Sb-1" was substituted for "Sb-2" in this combination, the benefit would be increased by $360, but the cost of the combination would be increased by $900. These benefit-cost evaluations of structural measures are shown in Table 2. While the combination of the structure and "Sb-1" maximizes the annual benefit and provides a favorable benefit-cost ratio, it does not maximize <u>net benefits</u>. Therefore, the combination of structural measures which includes "Sb-2" is selected as the most economical plan.

Table 1 - Flood and Sediment Benefits Afforded by Several Evaluated Structural Measures

	Average annual damage	Reduction in Average Annual Damages: Land treatment meas.	Structure 1/ alone	Sb-1 alone 2/	Sb-2 alone 3/	Structure + Sb-2	Structure + Sb-1
Flood damage	1,310	400	750	--	--	750	750
Reduction of sediment by sources:							
Sheet erosion	2,220	1,770	140	--	--	140	140
Streambanks above struc. 4/	200	--	200	--	--	200	200
Streambanks below structure	1,780	--	--	1,780	890	1,420	1,780
Other sources	280	--	90	--	--	90	90
Total	5,790	2,170	1,180	1,780	890	2,600	2,960

1/ Floodwater-retarding structure
2/ Streambank stabilization, Type 1
3/ Streambank stabilization, Type 2
4/ This benefit is considered to result from prevention of sediment coming from stream banks above the floodwater-retarding structure, although a minor portion may occur through reducing flood flows in the stream channel below the structure.

Table 2 - Comparison of Benefits and Costs of Several Structural Measures Considered in Program Formulation

Structural measures Evaluated	Annual Cost	Annual benefit	Net benefit	Benefit-cost ratio
Floodwater-retarding structure alone	1,020	1,180	160	1.16 to 1
Streambank stabilization:				
Sb-1 alone	1,910	1,780	-130	.93 to 1
Sb-2 alone	1,010	890	-120	.88 to 1
Structure plus Sb-2	2,030	2,600	570	1.28 to 1
Structure plus Sb-1	2,930	2,960	30	1.01 to 1

III. PLANNING FUNCTIONALLY DEPENDENT SINGLE-PURPOSE STRUCTURES TO MAXIMIZE THEIR NET BENEFITS

A simplified demonstration of the application of the principle of maximization of net benefits in program formulation where functionally dependent single-purpose structures are under consideration is presented below:

Floodwater-Retarding Structure	Benefit ($)	Cost ($)	Net Benefit ($)	Benefit-Cost Comparison
		CASE I		
A operating separately	2,000	1,700	+300	Favorable
B operating separately	2,500	2,900	-400	Unfavorable
A & B operating as a unit	5,300	4,600	+700	Favorable
		CASE II		
A operating separately	2,500	3,000	-500	Unfavorable
B operating separately	3,000	3,400	-400	Unfavorable
A & B operating as a unit	6,700	6,400	+300	Favorable
		CASE III		
A operating separately	3,200	1,500	+1,700	Favorable
B operating separately	3,500	3,300	+200	Favorable
A & B operating as a unit	7,300	4,800	+2,500	Favorable

In Case I, one of the structures is not justified when operating separately but when the two structures operate as a unit their effectiveness is increased to the extent that the net benefit is greater than that of either structure operating separately.

In Case II, neither structure is justified operating separately, but operating in combination as a unit the net benefit is greater than that of either operating separately.

In Case III, each structure operating separately is justified, but net benefits of the two structures operating as a unit are greater than that of either operating separately.

Application of the principle of maximization of net benefits in program formulation would indicate that in each case both structures would be recommended.

CHAPTER 6

EVALUATION OF STRUCTURAL MEASURES FOR FLOOD PREVENTION

I. LAND-STABILIZATION MEASURES

Land-stabilization measures are defined in Section 5 of the Handbook as being "installed primarily for the purpose of preventing land destruction and the production of damaging sediment which affects groups of landowners, communities and the general public". Such measures may be considered for stabilization of gullies, streambanks, roadsides, critical runoff and sediment-producing areas, for development of interfarm waterways and fire protection. They should be subjected to careful analysis in project formulation and evaluation, for in many cases there are alternate sets of measures that could be used. The choice may depend upon which will do the job at the lowest cost. For example, suppose that there is a critical sediment-source area above a proposed floodwater-retarding structure and a drop structure is proposed for the sole purpose of trapping sediment. The problem should be analyzed to determine whether it is cheaper to build the drop structure or to make provision for storage of the sediment in a floodwater-retarding structure. This statement of the evaluation of benefits and costs of land-stabilization measures is couched in general terms as these measures may be designed to solve many flood-prevention problems. Individual cases should be analyzed within the framework of physical facts and feasibility and sound economic principles.

A. Off-Site Benefits.

In general, off-site benefits may be considered as accruing to someone who has no control over the source of damage. The presence of off-site benefits is the primary reason for Federal participation in cost of installation. In the example of the critical sediment-producing area, off-site benefits may result from control of the sediment output in the form of a decrease in rate of channel filling and the resulting flooding in the stream below, or a reduction in damage to flood plain land from deposition of overwash. A similar situation arises when a streambank is stabilized. Here the protective works are installed adjacent to the area receiving benefit, but the water which causes bank cutting came from upstream. Therefore, reduction of damage to land, as well as downstream sediment damage, would be classed as off-site benefits. Likewise, reduction of land damage by stabilization structures installed to reduce off-site sediment and floodwater damage would be classified as an off-site benefit. Off-site benefits may be measured in the following terms:

1. They may be measured in the form of reduced cost or lengthened life of proposed or existing improvements. In this case, off-site benefits of our proposed structures can be used only in program formulation; i.e., to determine whether to include stabilization measures as a part of a

group of interdependent structures. For example, if our proposed retarding structure is economically justified and stabilization of the gully is cheaper than providing sediment storage in the proposed structure, the stabilization measure would be justified and included as a part of the project.

2. They may be measured in terms of reduced cost of operation and maintenance of facilities such as drainage ditches, reservoirs and other. For example, a heavy sediment load in a stream may cause such extensive channel filling that it is necessary to clean out at frequent intervals. In such a case, benefits could arise from reduction in the cost of cleaning out the channel.

3. These benefits may also be measured in terms of reduction in other forms of floodwater and sediment damage, such as:

a. Reduction in erosion and sediment damage to agricultural land.

(1) Overwash, swamping, streambank and gully erosion.

b. Reduction of gully and streambank erosion to land improvements.

c. Reduction of sediment damage to harbors, transportation facilities, reservoirs, municipal and industrial water supplies, drainage facilities and other downstream structures.

d. Reduction of roadside erosion damage.

e. Reduction of inundation damage to residential, industrial, crops, agricultural improvements, etc.

Where reduction in land damage on the flood plain is used as a benefit of stabilization measures, appropriate adjustments in estimates of other types of damage should be made. For example, when flood plain land is destroyed through streambank erosion, the crop and pasture damage during the life of the project must be reduced to take into account the progressively smaller area that will remain to sustain damage. In some instances, accrual of the full annual off-site benefit may be deferred. In such cases, appropriate discounting procedure should be used in calculating the average annual benefit.

B. On-Site Benefits.

Many stabilization measures produce both off-site and on-site benefits. For example, vegetative plantings for stabilization of critical runoff and sediment-producing areas will reduce downstream sediment and floodwater damage and simultaneously yield on-site benefits in the form of

increased net returns from cropping, grazing, timber production, etc. Also, structural measures for the stabilization of gullies such as drop inlets and detention-type terraces may reduce off-site sediment damage and simultaneously preserve the full value of production on land that would otherwise be encroached upon by gullies. In some instances, the installation of land-treatment measures cannot be safely or practically established without installing measures for stabilization of gullies and watercourses. Increased net returns over the amount that could be obtained without structural stabilization measures occurring on the drainage area of the structures are creditable to structural measures. These increased returns (on-site) are usually in the form of reduced crop income losses because of sheet erosion and increased net crop returns (over present returns) accruing on drainage areas above structures. In calculating the benefits of these stabilization measures, the cost of land-treatment measures (whose installation is made possible because of the stabilization measures) should be handled as associated costs (rather than project costs) in the benefit-cost analysis, in the same manner as indicated for calculating drainage and irrigation benefits - see Chapters 7 and 8; i.e., deducted from increased crop production values.

For certain types of stabilization measures downstream and other off-site benefits may accrue immediately after installation, but there may be considerable elapse of time before the maximum annual on-site benefit is realized. When this is the case, appropriate discounting procedures should be used in calculating the average annual benefit. Any lag in accrual of off-site benefits should also be properly discounted.

C. Project Costs.

Project costs of land-stabilization measures include installation and operation and maintenance. These costs should be measured on the same basis and in a manner comparable to the benefits.

1. Installation costs.

Installation costs should be converted to an average annual equivalent through amortization in order to be comparable with average annual benefit values. The period of amortization should be 50 years or the economic life of the measures, whichever is less.

Site costs should be a part of the installation costs. These costs may be unimportant in the case of streambank stabilization or gully stabilization, but may be a considerable factor in the vegetation of some critical areas. At times sites or easements may be purchased by local interests, in which case the funds expended are a measure of the cost. In other cases, the present worth of the income lost in the area involved may serve as the basis for estimating value of the site. The installation cost should always include the monetary cost or value of the site, or loss of income, whichever is greater when appraised on an equivalent basis.

2. Operation and maintenance costs.

The cost of maintaining works of improvement in such a condition that they will deliver the full benefit for which they were designed is another cost component. Maintenance costs may vary from year to year; however, in economic appraisal the best estimate that can be made of average costs over the period of analysis should be used.

Another item of annual cost is operation of the works of improvement. When automatically operating measures, such as drop structures, are concerned operating costs are generally nil. The annually recurring costs of some vegetative practices, such as fertilizer, when a grass seed or hay crop is harvested on a critical silt-source area that has been seeded, can be deducted from income as an associated cost. A few measures may have considerable operating costs. Fire control, where the salary and expenses of employing a forester are operating costs, is a good example.

3. Examples of the economic analysis of land-stabilization measures:

Example A -

a. There is a critical sediment-source area, 50 acres in extent, located above a site for a floodwater-retarding structure.

b. The area is now in poor cropland giving an annual net return of $10 per acre, and is being destroyed by gully erosion at the rate of 2 acres per year.

c. There is a 20-acre flood plain, presently producing an annual net income of $20 per acre, located between the floodwater-retarding structure site and the sediment source area. This flood plain is being damaged by overwash deposition with an annual decline in net income of $1.00 per acre.

d. Control of the sediment-producing area will permit a reduction in the sediment pool of the floodwater-retarding structure of 250 acre-feet at a savings of $18,750.

e. Installation of proper vegetative control measures plus a drop structure will cost $20,000 and annual maintenance will be $250.

f. Five years after the control measures are installed, the harvest of pasture from controlled grazing on the sediment-source area will give a net annual income, after deducting all associated costs, of $1.00 per acre.

g. Cost analysis:

(1) The annual equivalent cost of installing the measures, amortized at 2½ percent will be $705. Maintenance costs will add $250 annually.

(2) There will also be the income that the sediment-source area would have produced, but which must be foregone because of the project. This is figured as an annuity at 4 percent, beginning at $500 and decreasing at the rate of $20 per year for 25 years until it becomes zero. This value, $4,689, represents an annual equivalent of $188.

Installation cost	$ 705
Maintenance	250
Income foregone	188
Total annual equivalent cost	$1,143

h. Benefit analysis:

(1) The annual equivalent of the benefit from reduction in size of the sediment pool, at 2½ percent, will be $661.

(2) After 19 years of damage at the present rate, the 20-acre flood plain area will no longer be profitable for cultivation. It will be converted to pasture with a sustained net annual production of $1.00 per acre. If there was no damage, the capitalized value of production in the area would be $20 x 25 x 20 acres - $10,000. With damage, the eventual return, capitalized, would be $1 x 25 x 20 acres - $500. To this should be added the value of the decreasing annuity while production is declining at the rate of $20 per year, or $2,933. The total value with damage, $2,933, plus $500 is subtracted from $10,000 and the remainder is converted to an annual equivalent at 4 percent. This sum, $263, represents the annual benefit from this source.

(3) An on-site benefit of $50 per year will accrue from the sediment-source area, beginning in 5 years. The annual equivalent of this benefit will be $41.

Reduction in sediment pool	$661
Reduction in overbank deposition	263
On-site	41
Total annual benefit	$965

In the case assumed here, the measures would not be justified. In the above example, the "reduction in sediment pool" benefit would be used only in program formulation; i.e., to determine whether it is more economic to provide sediment space in floodwater-retarding structures or to stop its entry by stabilization structural measures. The analysis concerns a group of structures expected to function as a unit. Therefore, in the above case, had the reduction in sediment pool benefit been sufficient to include the stabilization measure in the project, the benefit from "reduction in sediment pool" would not be included as a benefit to the group of measures proposed. Actually, this value would be reflected in reduced cost of retarding structures and enter into the benefit-cost equation in this manner.

Example B -

In this example, the land-stabilization measures are gully or waterway stabilization structures for the purpose of reducing off-site floodwater, sediment and erosion damage. (Gully erosion damage by head cutting is considered an off-site benefit.) Installation stabilization structures will make possible further watershed protection and improvement by installing land-treatment measures on the drainage area above the structures. The on-site benefits made possible by stabilizing gullies or watercourses consist of both increased productivity and prevention of decline in productivity (decline through sheet erosion). Each of these result in a greater return on the drainage area of the structures than would be received if stabilization structures were not to be built. The increased net return is credited to stabilization structures. Calculation of this benefit takes into account cost of installing, operating and maintaining land-treatment measures. These costs are handled as <u>associated costs</u> and deducted from the expected increase in value of crop production in calculating the benefit.

Area subject to benefit (area above structure)	160 acres
Present gross value of production minus production costs	$2,400
Future gross value of production minus production costs	$3,680
Associated costs (cost of land-treatment measures)	
Construction $6,400 x .04655 (amortization factor)	$ 298
Technical assistance 400 x .035258 (amortization factor)	14
Operation and maintenance	640
Average annual equivalent	$ 952
Benefit calculation (increase over present income)	

$3,680 - 2,400 - 952 = $328

(Where the lag in time of accrual of benefits is significant, discounting should be employed.)

This increased productivity benefit ($328) is creditable to structural land-stabilization measures and may be used to justify their installation. In addition, the stabilization measures in this example have the following benefits: prevention of sheet and gully erosion damage and reduced sediment damage.

Methods for calculating sheet and gully erosion damage are shown in preceding chapters. However, the following calculations are applicable to the 160-acre drainage area above the structure subject to benefit:

Gully erosion

Area above structure subject to benefit	160 acres
Income on land subject to gully erosion (present)	$2,400
Annual rate of conversion to lower income use	4 acres
Maximum period over which damage can occur $\frac{160}{4}$	40 years
Income from gullied land	$640
Income loss due to gullying ($2,400 - $640)	$1,760
Average annual damage	
$1,760/40 x 306.32307 1/	$13,748
$1,760/.04 x .20829	9,165
	$22,643
$22,643 x .04	$ 906

Sheet erosion

Average annual damage with gullying $2/ac x 160	$320
Adjustment due to conversion to protective cover because of gully erosion and field dissection	
$320/40 x 505.18065 2/	$161

Benefit-Cost comparison

Off-site benefits	
Sediment damage reduction	$160
Gully erosion	960
On-site benefits	
Increased productivity	328
Reduced sheet erosion damage	161
Total Average Annual Benefit	$1,555

1/ Increasing annuity factor, 40 years, 4% interest
2/ Decreasing annuity factor, 40 years, 4% interest

Cost of stabilization measures (project costs)

Installation cost $4,000 x .046550[3]	$ 186
$16,000 x .035258[4]	564
Operations and maintenance	700
Total Average Annual Cost	$1,450
Benefit-Cost Ratio	1.07 - 1

II. WATERFLOW CONTROL MEASURES

Much of the discussion in Part I of this Chapter in land-stabilization is pertinent to the evaluation of waterflow-control measures.

A. Off-Site Benefits

The principal justification for waterflow-control measures will usually come from off-site benefits, either in the form of reduction of damage or in increased income. Details of the methods for calculating damage reduction can be found in Chapters 2 and 3. Chapter 4 deals with measurement of increased value of production.

Several distinct types of measures for waterflow control may be incorporated in a single work plan. For example, it may be found that floodwater-retarding structures form the nucleus of the control. There may be a small drainage area or two that cannot be economically controlled by such a structure, but the runoff may be diverted into a nearby floodwater-retarding structure by means of a diversion dike. In the lower reaches of the main stem perhaps the channel is silted and flooding is so frequent that control cannot be achieved by means of floodwater-retarding structures alone and it is necessary to include channel improvement or floodways in the plan. When such a combination of measures is needed, the approach described in Chapter 5 should be used in the evaluation. This will involve determination of the damages left after the land-treatment measures have been installed, and the successive reduction in damage as a result of installing floodwater-retarding structures, the diversion, and the floodway. A determination should also be made of the benefits from changed land use in the flood plain. (See Chapter 4)

Benefits from reduction in damage as a result of the installation of waterflow-control measures generally begin to accrue as soon as the measures are installed and need no discounting for time lag. The chief exceptions to this rule will be when damaged areas are restored to

3/ Amortization factor, 4% interest, 50 years (non-Federal cost)
4/ Amortization factor, 2½% interest, 50 years (Federal cost)

their former productivity. Such restoration usually will take time and the need for proper discounting should be considered.

An attempt to provide complete flood protection will ordinarily be uneconomic. If the program is installed and the flood plain is used more intensively as a result of the protection afforded, it can be expected that remaining floods will cause more damage than they would under existing land uses. The increased income from intensification should be adjusted to account for this condition.

To illustrate a possible procedure for estimating the necessary correction, the following example is given:

Original gross value of crops, per acre of flood plain, annually	$27.48
Gross value of crops in intensified area after intensification per acre, annually	32.82
Total flood plain, acres	$16,300.00

After installing the program, the seven largest floods in 20 years, and the damages caused (original land use and value of production) would be:

Acres Flooded	Crop and Pasture Damage
12,200	156,000
12,000	132,000
8,000	80,000
6,000	30,500
5,600	28,000
5,150	25,500
5,150	47,000
54,100	499,000

The acreage above the elevation that floods 5,150 acres would be flooded less often than once in three years. Thus the area subject to intensification would be 16,300 - 5,150 or 11,150 acres.

The next step is to determine the amount of flood damage to the original crop value on this 11,150 acres after installation of the program; 7 x 5,150 = 36,050 acres. Then 54,100 - 36,050 = 18,050 acres of the intensified area flooded one or more times in 20 years. 18,050 divided by 54,100 = 0.3336. This area is 33.36 percent of the total area flooded by these storms and the damage should not be greater than 33.36 percent of the total damage from these floods. $449,000 (total damage) x .3336 = $166,466 (damage on the intensified area). The average annual damage would be $166,466 ÷ 20 or $8,323.

The original crop value on this area was \$11,150 x \$27.48 or \$306,402; \$8,323 ÷ \$306,402 or 2.72 percent of the gross crop value was damaged by these floods.

The value after intensification is \$32.82 x \$11,150 or \$365,943. The gain in value from intensification is \$365,943 - \$306,402 or \$59,541. Assuming that the added value will be damaged at the same rate as the original value, we would have \$59,541 x .0272 or \$1,620. This is the amount to deduct from the increased income from more intensive use of flood plain land to account for increased damage.

Benefits from changed use of the flood plain also may need to be discounted. It will take time for clearing and land use conversions and these changes are not likely to be begun until after the control structures are in place and flooding is reduced.

Sometimes the evaluation may include an item for reduction of damage to future development in the flood plain in the absence of a project. This is a legitimate benefit provided that the future development has been appraised properly. In the case of agricultural production it would seem that good prices during the period since 1941 could have been expected to have stimulated agricultural development to such a great extent that further development could reasonably be expected only in exceptional cases. In many instances small rural towns have declined in importance and size during the last two or three decades, so future development of such communities seems improbable. The chief likelihood of future development seems to be where there is a growing city located within the flood plain. Whenever such an assumption as future development is used, there should always be an extremely careful study of trends and other economic factors to substantiate the assumption. Benefits from this source should be discounted to present worth whenever they are used. Great care must be taken to prevent duplication of benefits claimed from this source with benefits from damaged land use in flood plain lands.

Watershed protection works will have some effect on the flood plain downstream from the small watershed. Whenever flood routing is done below a creek watershed on which a work plan is being developed, consideration should be given to an analysis that will give the creek watershed its proportionate share of the benefits that can be expected from reduction of downstream flooding. On the other hand, when channel improvement, floodways or other measures to speed up the flow of water are the principal measures for waterflow control, consideration should be given to the added flood damage downstream that may result from the more rapid concentration of water.

An important technical problem that arises in the evaluation of the benefits from floodwater-retarding structures is the collaboration between the hydrologist and the economist in determining the

acreages involved. The flood routing to determine damages under existing conditions and after land-treatment measures have been installed, may be done before floodwater-retarding structure sites have been determined. When these sites have been located, it may be that part of the flood plain on which previous routing has been made will be included within the reservoir area. It can be seen that unless adjustments are made in the appraisals under existing conditions and after land treatment, subtraction of the damage after structures from the damage after land treatment would include the damage within the reservoir area as a benefit to the structure. Adjustments in the areas in which damages are estimated and benefits are claimed also will be needed when floodways are installed and their benefits evaluated.

B. On-Site Benefits.

Such waterflow-control measures as detention-type terraces and water-spreading devices may give important on-site benefits. These benefits may be measured through an approach similar to that used in appraising on-site effects of land-treatment measures.

On-site benefits may be available within the site of a floodwater-retarding structure. Such on-site benefits might accrue from fish culture, recreation and use of the sediment pool for stockwater, irrigation or domestic water supply. These benefits are not usually evaluated in monetary terms. Evaluation of the benefits from other uses should take into account the fact that the sediment pool is designed to store sediment and its ability to furnish incidental benefits will decline steadily through the project life. Any benefits claimed should be discounted on this account. Evaluation of benefits when used for irrigation should give recognition to the fact that the sediment pool cannot be expected to furnish a dependable water supply for irrigation. Any evaluation of on-site benefits from floodwater-retarding structures should take cognizance of State laws regarding water use. For example, in some states prior appropriation has been made for certain downstream uses. Provision has to be made here for drainage of the sediment pool on demand, and no firm on-site benefits can be claimed for its use.

C. Costs.

1. Project costs.

Included in the project costs are all costs of construction, including design, engineering, inspection and allowance for contingency. The value of lands, easements, rights-of-way, and the cost of relocating facilities moved because of construction of the waterflow-control measures are to be included. The value of the lands or easements should be compared with the equivalent value of production lost in the project area and the greater of the two included as a project cost.

In calculating the loss of net income in areas to be covered by the pools of floodwater-retarding structures the existing land use and yields in the areas are determined. It can be assumed that productive crop and pasture use would be lost from the entire acreage in the sediment reserve pool. Taxes and overhead are calculated separately for cropland and pasture and the savings from this source are deducted from the loss in income. This loss of income is further reduced by the annual amortization and interest charge on the sum allowed for site acquisition. Correction can also be made for the flood damage sustained under existing conditions that will be eliminated in the pool area.

An example of a method of calculation of loss in production in reservoir pools follows:

Table 1 - Area Involved in Floodwater-Retarding Structure Sites (23 structures), Existing Conditions

Item	Crop	Pasture	Total
Acres flood plain in sediment reserve pool	69	230	299
Acres flood plain in flood pool	92	345	437
Acres above flood plain in sediment reserve pool	184	713	897
Acres above flood plain in flood pool	299	989	1,288
Total Area	644	2,277	2,921

Table 2 - Area Involved in Floodwater-Retarding Structure Sites (23 structures), After Construction

Item	Water	Crop	Pasture	Total
Acres flood plain in sediment reserve pool	299	0	0	299
Acres flood plain in flood pool	0	0	437	437
Acres above flood plain in sediment reserve pool	897	0	0	897
Acres above flood plain in flood pool	0	0	1,288	1,288
Total Area	1,196	0	1,725	2,921

The next step is to calculate the net income from agricultural production, "before" and "after".

Table 3 - Net Value of Agricultural Production in Area Involved in Floodwater-Retarding Structure Sites (23 structures) Existing Conditions

Land Use	Acres	Yield	Price	Gross Value	Cost of Production
Bottom Land					
Corn	18.5	32	$ 1.25	$ 740	$ 398
Wheat	20.4	21	1.91	818	319
Cotton	33.7	240	0.328	2,653	1,591
Alfalfa	52.3	3	21.88	3,433	1,849
Peanuts	9.2	750	0.102	704	254
Meadow	7.1	1.5	17.49	186	107
Gr. Sorghum	18.7	14	2.04	534	260
Sorghum	1.1	2	15.00	33	15
Pasture	575.0	2.5	2.70	3,881	288
Upland					
Corn	28.0	18	1.25	630	410
Wheat	227.5	12	1.91	5,214	2,821
Cotton	62.8	184	0.328	3,790	2,346
Alfalfa	33.8	1.5	21.68	1,099	704
Meadow	19.8	1.2	17.49	416	250
Gr. Sorghum	38.6	8	2.04	630	425
Oats	72.5	22	0.76	1,212	834
Pasture	1,702.0	0.9	2.70	4,136	851
Total	2,921.0			$30,109	$13,722
Net Income				$16,387	

Table 4 - Net Value of Agricultural Production in Area Involved in Floodwater-Retarding Structure Sites (23 structures) After Construction

Land Use	Acres	Yield	Price	Gross Value	Cost of Production
Bottom Land					
Pasture	437	2.5	$ 2.70	$2,950	$ 218
Upland					
Pasture	1,288	0.9	2.70	3,130	644
Total	1,725			$6,080	$862
Net Income				$5,218	

The reduction in net income from the pool areas is thus found to be \$11,169 annually under present price levels or about \$8,900 under long-term prices. The acreage in crops will be reduced by 644 and that in pasture by 552 acres. In this area the overhead and tax charges assigned to cropland were \$2.50 per acre and \$0.50 to pasture. Thus the change in land use would result in a reduced charge for overhead and taxes of about \$1,900. The annual interest and amortization charge on the cost allowed for site acquisition would be \$5,500. The existing flood damage to production in the area averages \$1,000 annually. These calculations can be summarized as follows:

Net loss in income, including taxes and overhead	\$8,900
Deduction for taxes and overhead	1,900
Deduction for existing flood damage	1,000
Deduction for annual interest and amortization charge	5,500
Net loss in income (negative project benefit) to be added to "other economic costs" of project	\$ 500

It is not expected that waterflow-control measures will normally be so located that they will displace production from industrial, mining or urban areas. If they are so located, adequate accounting should be made of the production lost. Similar accounting should be made if the measure is a floodway, levee or other waterflow-control measure.

The principle of maximizing net benefits is discussed in Chapter 5. Increments should be added to the project as long as each increment provides an increment of benefit greater than its cost. It is necessary to make sure during project formulation that uneconomic increments are not added to the project. One step in the testing process is to analyze benefits and costs and obtain a benefit-cost ratio for each major phase of the project. Thus separate evaluations should be made for floodwater-retarding structures, floodways, channel improvement, etc. Separate evaluations should be made when the benefits from measures or groups of measures are geographically separable. An example of this condition would be when there are two distinct areas of channel improvement included in a watershed plan. Such a condition also will occur when floodwater-retarding structures are planned on several laterals included in the same plan.

There are sometimes cases where two phases of a project may be interdependent. Perhaps neither floodwater-retarding structures nor floodways will be economically justified alone but in combination both will be economically feasible. This may happen when the control afforded by the structures is sufficient to greatly reduce the cost of the floodways. The two measures should be evaluated jointly in this case, the several combinations of structures and floodways should be tested in order to obtain the most efficient combination.

2. Operation and maintenance costs.

Operation costs of measures for waterflow control are likely to be rather small as the structures usually operate automatically.

Maintenance costs should be set at a figure high enough to insure full efficiency through the life of the project. Failure to provide sufficient funds for maintenance may result in a failure that would cause damage several times as great as would occur in the absence of the project.

3. Associated costs.

Associated costs are involved chiefly in calculating benefits from changed land use. Additional costs connected with changed use of the land, such as conversion from pasture to cropland, clearing and grubbing woods, farm drainage and the like are amortized and deducted from the increased income. Remaining flood damage to the more valuable production is treated in the same fashion. It is quite possible that the intensified area, having become more productive, will be taxed more heavily. Additional barns, granaries and equipment may be needed to handle the additional production. The associated costs therefore may include an item for taxes and overhead. The usual costs of the farm operations involved in crop production form another item of associated costs for deduction from the gross income.

The treatment of the costs of crop production is a little different in the analysis of damage. When a crop is destroyed by flood, the full cost of the operations yet to be performed is subtracted from the damage as expense not incurred. If the crop is flooded early and replanting is necessary, the full cost of the added operations is included in the damage estimate. The term "full cost" includes the value of unpaid family labor and interest and depreciation on machinery as well as out-of-pocket cash costs.

Although associated costs do not appear in the benefit-cost ratio, it can be seen that their careful appraisal is most important. Because they are deducted from the gross benefit, they determine the size of the benefit used in economic analysis. They have almost equal importance as a supplementary economic tool in determining whether or not appraisals of damages and benefits are realistic. For example, the comparative spreads between gross income and associated costs is of high importance in estimating the amount of floodwater or sediment damage a farmer will take before letting his flood plain lands lie idle, and the degree of protection he will require before he intensifies his land use.

CHAPTER 7

EVALUATION OF DRAINAGE MEASURES

I. ON-SITE BENEFITS

Benefits resulting from drainage measures are largely on-site. The following types of on-site benefits may be included: (1) Increases in gross value of production with and without the drainage project, less any increases in crop production costs or other costs, such as increased harvesting, storing and marketing costs, and (2) other benefits, although not evaluated monetarily, include items such as improved wildlife habitat and production, reduction of health hazards, etc.

A. Methods.

Determine by use of schedules and by field inspections present average land use and yields (without drainage) and anticipated land use and yields (with drainage). If necessary, pertinent information on costs of production with and without drainage may be obtained from farmers effected at the same time. Such field information should be supplemented by and checked against secondary sources and reports from like areas where drainage improvements have been installed. It is desirable to obtain information on present and anticipated land use and yields by land capability classes, subclasses, or by soil mapping units, whichever is most applicable. This provides for a check on physical feasibility as related to economic feasibility. Aerial photographs with soil survey or capability data recorded on them can be taken to the field for the purpose of identifying crop and yield data by capability class or soil mapping units. After sufficient sample has been obtained, average yields, costs of production and income by crops per acre can be developed by land classes. These data can be used for expansion to larger areas by land classes.

In determining benefits to drainage measures, it is important to separate increases in income or other benefits due to drainage from increases in income due to better managerial practices which could be followed in absence of the project. This may be done, to a reasonable extent, by local farmer interviews and consultation with local technicians or agricultural workers. Results obtained by drainage on like areas, if available, can be used as a check on land use increases in yields or income that may be expected.

Table 1 is a sample of a convenient form for recording basic data on land use and yields.

B. Summary of On-Site Benefits.

The process of developing an estimate of on-site benefits can be summarized in a work table such as shown in Table 2. This helps the technician in accounting for total area and income effected by proposed drainage.

C. Amortization, Interest Rates, Prices and Discounting.

The general instructions given in Chapter 1 of this Guide will be used as applicable.

II. OFF-SITE BENEFITS

Some floodwater-damage reductions may result from stream channel improvement and construction of lateral ditches or drainage canals needed to provide sufficient outlet for farm land drainage. Where works of improvement are primarily for drainage, an estimate of floodwater damages with and without the program should be made. A decrease in floodwater damages would be a benefit.

A. Methods.

Use method adapted to situation as outlined in Chapter 2.

III. COSTS

A realistic appraisal of all costs is just as important as an adequate appraisal of benefits. Local practices in contracting, availability of contractors and needed equipment, costs of similar jobs and physical conditions which would affect costs should all be taken into consideration in working up cost estimates.

Costs such as contingencies, legal fees, installation services and annual maintenance can be estimated as a percentage of construction costs. It is recommended that these percentages be worked out to suit localized areas where conditions are alike.

A. Project Costs.

Project costs may include, but are not limited to, the types of costs listed below. These may in various combinations make up installation costs or be a part of annual maintenance costs. General instructions as given in the Handbook are to be followed as applicable:

Easements and rights-of-way
Clearing right-of-way
Relocation or rebuilding of roads, bridges, culverts and fences
Excavation of main canals, ditches and laterals
Stabilization of canals, ditches, or laterals
Motors and pumps
Legal fees
Contingencies
Interest on investment (usually accounted for in amortization)

Installation services in field surveys, design,
preparation of specifications, contracting,
layout and supervision
Annual maintenance

Table 3 is given as an example of a form for tabulating and summarizing project installation and operation and maintenance costs.

B. Associated Costs.

Examples of associated costs for a drainage project would include increases in harvesting costs and increased costs of subsequent processing, such as ginning costs for cotton; any increases in costs of crop or pasture production; on-farm field drains; land clearing; land conditioning; fencing; pasture development; additional taxes, annual maintenance costs on fences, field drains, pastures, etc. An increase in floodwater damages, usually due to more intensive cropping and higher damageable values, may also be treated as an associated cost.

C. Induced Costs.

All induced costs, as defined in Section 6, of the Handbook, should be taken into account where necessary in preparing a cost-benefit ratio for drainage projects. In the analysis, these are handled in the same manner as are project costs. An increase in floodwater damages (usually due to more intensive cropping and higher damageable values) can be treated as an induced cost. (Although not evaluated monetarily, it is necessary to consider and describe any damaging effects to fish and wildlife by drainage projects.)

D. Methods and Summarization.

Items such as increased crop production costs will be estimated to begin with on an annual basis. Other items such as fencing, pasture development, or clearing will first be estimated as a total cost. To convert the total cost of these individual items to an annual equivalent amount, use the appropriate amortization factor for the expected economic life of each at local prevailing private interest rate. For example, fencing may cost a total of $1,000. Suppose it has an assumed economic life of 20 years, and that the private interest rate is 4 percent. The amortization factor, at 4 percent for 20 years, is .07358 (see Compound interest and annuity table). $1,000 x .07358 = $7.36 or the average annual equivalent cost. For clearing it will be permissible to use a 50-year amortization period in calculating annual equivalent cost.

All costs should be summarized on an annual or annual equivalent basis. A work sheet can be used to tabulate and total costs of production by crops or land uses <u>with</u> and <u>without</u> drainage.

Table 1

Watershed ______________

Date ______________

Farm owner/operator ______________ Address ______________

Total area effected ______________ acres

Land Unit[1]	Acres	Cap. Class	Without Drainage: Land Use	Without Drainage: Yield/ac	With Drainage: Land Use	With Drainage: Yield/ac

1/ Field, capability class or subclass, soil mapping unit, etc.

Table 2 - Project Benefits

Watershed ______________ State ______________ Prices Used ______

Land Class	Without Drainage				With Drainage			
	Land Use and Acres 1/	Yield Per Acre	Annual Gross Income Per Acre	Total Annual Gross Income	Land Use and Acres 1/	Yield Per Acre	Annual Gross Income Per Acre	Total Annual Gross Income
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Total		xxx	xxx			xxx	xxx	

1. Gross income with program (total Col. (9)). . . . . $______
2. Gross income without program (total Col. (5)) . . . . $______
3. Difference. . . . . $______
4. Total annual associated costs 2/ . . . . $______
5. Total annual benefits . . . . $______

Subtract item 2 from item 1 to obtain item 3
Subtract item 4 from item 3 to obtain item 5

1/ Major crops or land uses can be listed and evaluated by land classes.
2/ Growing, harvesting, storing and marketing costs, and other on-farm costs, such as field drains, land clearing and conditioning, fencing, etc.

Table 3 - Project Costs

Watershed ____________ State ____________ Prices Used ____________

Item	Unit	Quantity	Unit Cost	Installation Costs			Annual Operation and Maintenance Costs
				Federal	Non-Federal	Total	
Total Costs	xx	xxxx	xxxxx				

Average Annual Installation Cost $__________
Annual Operation and Maintenance Cost $__________
Total Annual Cost $__________

Table 4

Project Costs, Benefits and Benefit-Cost Comparison

______________________ Watershed

COSTS

	Installation	Average Annual Cost			
		Amortization	O & M	Induced	Total
	($)	($)	($)	($)	($)
Project Costs:					
Induced Costs:					
TOTAL					

BENEFITS

	Average Annual Benefit
	($)
Drainage (increased net income):	
Flood Damage Reduction:	
TOTAL	

Benefit-Cost Ratio	

CHAPTER 8

EVALUATION OF IRRIGATION MEASURES

I. BENEFITS

Benefits resulting from irrigation measures are mainly on-site and may include the following: (1) Increases in gross value of production with and without the irrigation project, less any increases in crop production costs or other costs, such as increased harvesting, storing and marketing costs, and (2) other benefits, although not evaluated in monetary terms, such as improved wildlife habitat, reduction in health hazards, etc.

A. Methods.

Determine by use of schedules and field inspection, present land use and yields (without irrigation and probable land use and yields with irrigation). Pertinent information on cost of production with and without irrigation should be obtained at the same time. It is desirable that the above information be obtained by land capability classes, subclasses or by soil mapping units for appropriate subdivisions of the area to be effected by irrigation measures. Aerial photographs with soil survey or capability data recorded on them can be taken to the field for the purpose of identifying crop and yield data by capability classes or soil mapping units. After an adequate sample has been obtained, yields, production, costs of production and income by crops can be developed for appropriate units of the project and expanded to larger areas, where necessary, to cover the entire project area.

In determining benefits to irrigation measures, it is important to omit increases in income or other benefits which arise from better managerial practices. This may be done to a reasonable extent, through the exercise of judgment and by a careful check of results obtained by irrigation on comparable areas where such information is available.

Table 1 is a sample form that could be used for recording basic data on land use and crop yields.

II. COSTS

In evaluating irrigation measures, a number of different types and kinds of costs must be taken into account in the analysis. A realistic appraisal of costs is just as important as is an adequate appraisal of benefits.

A. Project Costs.

In general, the cost of establishing, maintaining and operating

off-farm irrigation measures is considered as a project cost. These may include, but are not limited to, the types of costs listed below:

Easements and rights-of-way
Reservoir, dam and appurtenant works
Diversion works
Canal excavation and realignment
Flumes
Headgates
Contingencies
Installation services
Annual operation and maintenance

B. Associated Costs.

In general, all on-farm capital costs and farm production operating and maintenance costs required in connection with irrigation facilities are considered as associated costs (as defined in Chapter 1).

C. Induced Costs.

All induced costs, as defined in Section 6, of the Handbook, should be taken into account where necessary in preparing a cost-benefit ratio for irrigation projects. In the analysis, these are handled in the same manner as are project costs.

III. ILLUSTRATED EXAMPLE OF AN IRRIGATION PROJECT EVALUATION

A. The following example illustrates a summary evaluation of an assumed irrigation project:

1. The assumed project presently has an inadequate late summer water supply which prevents full use of the land potentials. A multiple-purpose structure is proposed which will provide flood control and irrigation storage.

2. The irrigation features involve a share of the reservoir and dam, improvement of diversion works, and canal realignment and rehabilitation.

3. Thirty-four farms, containing 2,740 acres, are included within the irrigation system boundaries.

4. Land capability classes are:

190 acres - Class I; 1,440 acres - Class IIe; 610 acres - Class IIs; 320 acres - Class IIIw; 180 acres-Class IVe

Present Farm Conditions Without Project - Short Water Supply
Long-Term Prices

Crop	Acres	Yield	Net Income 1/ Per Acre	Total
Alfalfa	605	3 t.	$23.90	$14,460
Alsike Clover (seed)	160	4 cwt.	38.15	6,100
Irrigated pasture	550	5 aum.	23.60	12,980
Dryland pasture	410	2 aum.	6.10	2,500
Barley	270	40 bu.	12.00	3,240
Oats	220	50 bu.	7.10	1,560
Sugar beets	140	16 t.	62.20	8,710
Idle, garden, roads, farmsteads	385	lump	25.00 per garden (1 per farmstead)	850
	2,740			$50,400

Average per acre net income $18.39

Future Conditions With Project Installed
Long-Term Prices

Crop	Acres	Yield	Net Income 1/ Per Acre	Total
Alfalfa	685	4 t.	$ 39.20	$ 26,850
Alsike Clover	275	4 cwt.	38.15	10,490
Irrigated pasture	685	10 aum.	49.80	34,110
Barley	220	50 bu.	20.70	4,550
Oats	220	75 bu.	23.80	5,240
Sugar beets	380	22 t.	118.00	44,840
Idle, garden, roads, farmstead	275	lump	25.00	850
	2,740			$126,930

Average per acre net income $ 46.32

1/ Gross value of production less growing, harvesting, storing, marketing and all other crop production costs.

Summary of Project Installation Costs

Reservoir, dam and appurtenant works	$105,000
Diversion works	37,200
Canal excavation and realignment	21,300
Flume replacement	18,600
Headgate rehabilitation	9,700
Land leveling	56,400
Farm drainage	4,000
Revision of farm irrigation systems	16,880
Contingencies	23,000
Installation services	49,400
Total Project Installation Cost	$341,480

Amortization of Project Installation Cost

Item	Economic Life (years)	Interest Rate (%)	Amortization Factor	Total Cost ($)	Average Annual Equivalent Cost ($)
Dam & reservoir	50	5	.05478	105,000	5,752
Diversion works	50	$2\frac{1}{2}$	.03526 1/	43,900	1,548
Canals and contingencies	50	5	.05478 2/	65,900	3,610
Installation services	50	$2\frac{1}{2}$	.03526	49,400	1,742
				341,480	12,652

Amortization of Associated On-Farm Capital Costs

Item	Economic Life (years)	Interest Rate (%)	Amortization Factor	Total Cost ($)	Average Annual Equivalent Cost ($)
Land leveling	20	5	.08024	56,400	4,526
Farm drainage	20	5	.08024	4,000	321
Revision of farm irrigation syst.	20	5	.08024	16,880	1,354
				77,280	6,201

1/ Arbitrarily assumed that the Federal Government would share 40% of costs of distribution system and contingencies.

2/ Assumed that local interests would share 60% of distribution system and contingencies.

Summary of Annual Operation and Maintenance Costs

Dam and reservoir	$ 2,100
Diversions and canal systems	4,340
Flumes and headgates	1,115
Land leveling	2,800
Farm irrigation systems	840
Farm drainage	80
	$11,275

Summary of Benefits

Net income after improvement	$126,930
Net income before improvement	50,400
Increase in net income	76,530
Less associated costs	6,201
Net Benefits	$ 70,329

Benefit-Cost Analysis

Benefits:

Increase in annual net income	$70,329

Costs:

Annual operation and maintenance cost	11,275
Average annual equivalent project cost	12,652
Induced costs (loss in annual income from reservoir area)	1,000
Total Costs	$24,927

Benefit-Cost ratio $70,329 (Benefits) ÷ $24,927 (Costs) =

2.82 to 1

Table 1

Watershed ____________________

Date ____________________

Farm owner/operator ____________________ Address ____________________

Total area affected ____________________ Acres

Crop or Land Use				Average Yield Per Acre		
Without Irrigation Measures		With Irrigation Measures		Without Irrigation Measures	With Irrigation Measures	Remarks
Crop	Acres	Crop	Acres			

CHAPTER 9

EVALUATION OF OTHER AGRICULTURAL WATER-MANAGEMENT MEASURES

I. GENERAL

Public Law 566, 83rd Congress, authorizes the Federal Government to "cooperate with States and their political subdivisions, soil or water conservation districts, flood prevention or control districts, and other local public agencies for the purpose of . . . furthering the conservation, development, utilization, and disposal of water . . . ". Measures installed to achieve the foregoing purposes are referred to as water-management measures. Water-management measures are subdivided by broad purposes into irrigation measures, drainage measures and other water-management measures. The evaluation of irrigation and drainage measures is discussed in other chapters of this Guide. Hence, this chapter is confined to the evaluation of those measures which clearly do not fall within the usual concept of irrigation or drainage.

Other water-management measures include:

(1) Community water distribution measures to provide water for livestock.
(2) Measures for recharging groundwater.
(3) Watershed measures designed to improve the yield of water.
(4) Control of salt cedars or other phreatophytes of little or no economic value.

A. Evaluation of Community Livestock Water.

Scarcity of livestock water in some areas has prevented needed land use adjustments. Grass is generally marketed through livestock and stockwater must be available if the forage has a market value. In some areas an annual unit month of grazing has a net value of $2.50 to $5.00. An animal unit requires about 500 gallons of drinking water per month. Hence, the value of water for livestock use on this basis may be as high as $\frac{1}{2}$ to 1 cent per gallon, or $1,600 to $3,200 per acre-foot. This probably approximates the average cost of hauling water. It is obvious, however, that where stockwater is the limiting factor in the utilization and marketing of forage the economic justification for stockwater development may assume fantastic proportions. Hence, anticipated benefits would not impose any serious cost limitations on stockwater facilities. However, proper economic evaluation does require that relative costs of alternatives be considered so that net benefits are maximized.

Under this concept then, it may not be necessary to establish a productive value of water which at best is a difficult and complicated job. From an economic standpoint, the alternative that is most feasible is the one that satisfies the need for stockwater at the least <u>annual</u> cost. The annual cost consists of two components:

1. The amortization of the project cost over the life of the project, or 50 years, whichever is shorter.

2. The annual cost of operation and maintenance. It is apparent that a facility with low initial cost but high operation and maintenance cost may have a higher annual cost than one with a higher initial cost but lower operation and maintenance. This is illustrated by the following examples of two alternative stockwater facilities, either of which will satisfy the required needs for stockwater:

Type of Facility	Initial Cost	Expected Life
Stockwater well:		
Drilling well, casing, pipe	$3,000	50
Equipment, including windmill, pump, storage tank and drinking troughs	2,000	20
Total Initial Cost	$5,000	
Stockwater Reservoir (50 years sediment capacity):		
Dam and outlet	$6,000	50
Watering troughs, pipe and fencing	1,000	20
Total Initial Cost	$7,000	

	Annual Cost at 4½ Percent Interest
Stockwater well:	
Amortization	
Drilling well, casing and pipe (.0506)	$152
Equipment (.0769)	306
Operation and maintenance	250
Total Annual Cost	$708
Stockwater Reservoir:	
Amortization	
Dam and outlet (.0506)	$304
Equipment (.0769)	77
Operation and maintenance	100
Total Annual Cost	$481

In this example, a stockwater reservoir would return the same benefits as a well at about 68 percent of the cost even though the installation cost is 40 percent greater.

B. Evaluation of Measures to Increase Water Supply.

Measures for increasing ground water, improving water yield from watersheds or decreasing non-beneficial use all have one common purpose which is to increase the economic value of a watershed's water resources. Hence, the evaluation of benefits stemming from any of these measures is generally evaluated in the same way. The only justification for increasing or stabilizing streamflow is that present streamflow does not satisfy either the present or potential demand for it. To the extent that modified streamflow and improved water supply further satisfies the demand, it has an economic value.

The economic value of water may be considered to be either its net productive or use value or the cost of supplying it by the least costly alternative method, whichever is the smaller. In many parts of the arid section of the country the opportunities for augmenting the water supply by storage projects or transmountain diversions are limited either by undeveloped water supplies, which may be put into beneficial use, or the feasibility of such projects.

The productive value of water for agricultural use is dependent upon these factors:

1. The response of adapted crops (yield) and cropping patterns to additional water supply.

2. The market value of adapted crops.

3. Variable costs associated with the production and marketing of adapted crops.

4. Other non-project costs associated with the delivery and utilization of the additional water supply.

5. Consumptive use requirements of adapted crops.

6. Non-beneficial losses of the water supply from point of origin or recovery to point of measurement or use.

In areas presently irrigated considerable data are available on these factors. A study of crop yields in areas where water is not a limiting factor provides a good guide for the potential yields in similar areas if water shortages are eliminated. Similar projections may be made for cropping patterns providing the market outlets are similar. Because markets are seldom localized and because the increased supply of farm products in relation to the total market supply is small, it is generally safe to assume that the market price will be the same as prices that have prevailed in the past. Caution should be observed,

however, for those specialty crops that may now be used to satisfy local demand but with additional production would have to move to a distant market in competition with production from more favorable areas.

Where additional water supplies are used to augment existing supplies, without changing the area irrigated or the cropping pattern, variable production costs usually are confined to irrigation labor and harvesting costs. If there are significant changes in cropping patterns and new land is brought under irrigation, production costs with and without project conditions must be determined and any difference is the variable production cost taken into account. Other non-project costs that may be required to put the additional water to beneficial use such as distribution, storage or pumping costs should be evaluated. These costs, together with increases in variable production costs, comprise the associated costs.

Consumptive use requirements of crops for irrigation water are equal to the amount of water needed to grow crops to maturity with satisfactory yields under ordinary or average agronomic practices minus effective precipitation during the growing season. Hence, if the total consumptive use for alfalfa is 30 inches and the effective precipitation is 5 inches, 25 inches of water must be supplied by irrigation. This is the consumptive use requirement of alfalfa for irrigation water. These requirements for different crops vary from place to place depending on effective precipitation, relative humidity, temperature, daylight hours and length of growing season. Hence, they must be determined for localized areas. These requirements are sufficient only to meet the requirements for plant growth and do not allow for losses due to such factors as seepage from farm ditches, surface runoff, or deep percolation. These losses must be added to the consumptive use requirement to obtain the total requirement at the farm headgate where the water is generally measured.

Before the water reaches the farm headgate, additional losses must usually be considered. In the case of phreatophyte control, for example, the change in water consumed is first determined at the treated area. This may be several miles from the farm headgate and the increased water supply may be reduced in transit through several miles of stream channels, evaporation from reservoirs and irrigation laterals. All of these losses must be considered in arriving at the benefits of increased water supply.

To illustrate the method used for evaluating the benefits of water salvage, the following example is given for phreatophyte control where the additional water will alleviate present water shortages:

1. Conditions or Assumptions.

Amount of water salvaged at treatment area	1000 ac. ft.
Normal loss to farm headgate	25 percent
Normal loss to farm headgate	250 ac. ft.
Amount available at farm headgate.	750 ac. ft.
Farm irrigation efficiency	60 percent
Additional irrigation water available for consumptive use	450 ac. ft.
Area irrigated (present and future).	1800 acres

2. Estimated Present and Future Consumptive Use and Crop Yields Per Acre.

Crop	Acres 1/	Consumptive Use-Feet Present	Consumptive Use-Feet Future	Crop Yields Present	Crop Yields Future
Alfalfa	540	1026	1296	2.4 T.	3.0 T.
Barley	540	659	659	50 bu.	50 bu.
Corn	360	511	601	47 bu.	55 bu.
Sugar beets	360	644	734	13 T.	15 T.
Total	1800	2840	3290		

3. Calculation of Increased Net Return.

Crop	Increased Production	Value of Increase	Increased Variable Cost	Increased Net Return
Alfalfa	324 T.	$ 6,200	$ 2,200	$ 4,000
Barley	-	-	-	-
Corn	2880 bu.	4,030	1,150	2,880
Sugar beets	720 T.	8,460	3,420	5,040
Total		$18,690	$ 6,770	$11,920

In connection with Step 2, water supply studies are required to determine the adequacy of the present supply. In the foregoing example, it was found that barley, which matures early in the season with a low water requirement, was not limited in yield under average management practices by an inadequate supply. The other crop yields were limited by inadequate late season water. The estimated increases in yields were based on available data and the judgment of qualified individuals on the assumption that all other units of input, except water, remained constant. Whether or not this is a reasonable assumption in all cases depends on a number of factors. However, any improvements that increase the efficiency of water use should be evaluated separately unless it is determined that increased efficiency of water use is dependent upon increasing the water supply.

1/ No change in cropping pattern

Increases in variable costs should include all non-project costs which are necessary to secure the anticipated benefits. In irrigated areas the existing irrigation systems may require modification to handle the additional supply. If so, such costs should be taken into account as well as changes in "on the farm" costs. If the increased water supply stems from increased groundwater recharge, changes in pumping costs should be considered. This may require rather detailed studies of present and future groundwater depletion and pumping lifts.

Other agricultural water-management measures generally provide on-site benefits as well as the off-site benefits discussed above. Vegetative changes from deep rooted trees and shrubs of little or no economic value to adapted grasses that may be marketed through livestock, may result in significant on-site benefits. Measures designed to retard and prolong surface flow on underground water recharge areas may also result in increased forage production. The evaluation of these on-site benefits is done in the same way as the comparable on-site benefits of land-treatment measures. (See Chapter 8)

C. Summary of Evaluation of Other Water-Management Measures.

The general principles involved in the economic analysis of other water-management measures are not discussed in this section because they have been discussed in Chapter 1 and elsewhere. These same principles should be followed in the evaluation of these types of measures. The following check sheet may be helpful in identifying the most common types of benefits that will accrue from these measures, and the costs that should be considered. Although there are exceptions the principal types of benefits are underlined.

Benefits of Other Water-Management Measures

Type of Measure	On-Site Benefits	Off-Site Benefits
1. Community stockwater facilities	<u>Net increased value of livestock production attributable to facilities or alternative cost of providing stockwater, whichever is smaller.</u>	Relative contribution of this type of measure in combination with land-treatment in reducing floodwater and sediment damage and improvement of water yields.
2. Measures for recharging groundwater	Net increased value of crop and forage production on treated areas.	<u>Net value of increased water supply available for beneficial use.</u> Minor reduction of flood damage.

3. Watershed measures to improve water yields.	Net increased value of crop and forage production on treated area.	Net value of changes in seasonal or annual water supply. Minor reduction of flood damage.
4. Phreatophyte control.	Net increased value of crop and forage production on treated area. Increased flood damage, if any, due to land use changes treated as associated cost and deducted from benefit.	Net value of changes in water supply measured at point of use.

Costs of Other Water-Management Measures[1]

Type of Measure	Project Costs[2]	Associated Costs[3]
1. Community stock-water facilities	Cost of installing, operating and maintaining measures.	None when benefits are evaluated on basis of least costly alternatives. When benefits are based on productive value of water, associated costs include all costs of the livestock enterprise needed to market the water.
2. Measures for recharging groundwater	"	On-site benefits: Cost associated with utilizing and marketing additional forage production. Off-site benefits: None when benefits are evaluated on basis of least costly alternatives. When based on productive value of water, associated costs consist of changes of pumping costs and other variable production costs incurred in utilizing additional supply.
3. Watershed measures to improve water yields.	"	"
4. Phreatophyte control	"	"

The following footnotes apply to references indicated on preceding page:

1/ In some cases costs may include uncompensated adverse effects (induced costs). Where appropriate, they should be evaluated and shown as a cost in column 8 of table 3, of the work plan.

2/ Net installation costs (initial project costs minus present worth of salvage value) amortized at going interest rates in 50 years or life of measures, whichever is shorter. Operation and maintenance costs include all recurring costs (compensated or otherwise) that are necessary for the measures to operate effectively.

3/ Associated costs are deducted from benefits and only net benefits enter into the benefit-cost ratio.

APPENDIX A

DEFINITIONS OF CERTAIN TERMS

(To be furnished at a later date)

APPENDIX B - LAND DAMAGE

I. ALTERNATE METHODS OF EVALUATING EROSION AND SEDIMENT DAMAGE TO AGRICULTURAL LAND

These methods are all based on the supposition that productivity will continue to decrease more or less gradually and at about the rate that has prevailed over the period of cultivation or any other more suitable, applicable period. Present productivity, land use and income of land subject to future damage are used as the basis of evaluation. Also, the net income value used is calculated as gross value of production less crop production costs (growing, harvesting, storing and marketing costs).

Table 1

Net Income at Different Productivity Levels

Damage (%)	Productivity Level (%)	Gross Value of Production ($/ac)	Growing Cost ($/ac)	Harvest Storage Market Cost ($/ac)	Net Income ($/ac)	Net Income (Difference) ($/ac)
0	100	55.35	21.35	14.05	19.95 1/	
10	90	49.81	21.35	12.64	15.82 1/	4.13
20	80	44.28	21.35	11.24	11.69 1/	4.13
30	70	38.74	21.35	9.83	7.56 1/	4.13
40	60	33.21	21.35	8.43	3.43 1/	4.13
50	50				2.86 2/	.57
60	40				2.29 2/	.57
70	30				1.72 2/	.57
80	20				1.15 2/	.57
90	10				.58 2/	.57
100	0				0	.58

The following field information is used in the damage calculations:

- Area subject to future damage.
- Present use of above area.
- Average initial damage (damage at time of occurrence)
- Lag in beginning of productivity recovery.
- Maximum productivity recovery.
- Time elapse from initial damage to maximum recovery.
- Area and severity of observed damage.
- Period over which observed damage accrued.
- Anticipated rate (areal) of future damage.

1/ 0-40% damage based on crop production; over 40% damage based on lower income producing uses.
2/ Based on less profitable uses.

The method takes into account the fact that in most instances, the period over which a given rate of damage can occur is limited by either the area subject to damage, characteristics of the land, or the maximum decline in productivity and income expected.

Methods generally applicable to different field conditions are presented below for scour and streambank erosion, and overwash and swamping.

A. Field Condition I.

No increase in total area damaged is expected, however, it is expected that the present damaged area will further decline in productivity (yields) due to continued deposition or sedimentation. Also, no recovery of productivity without the program is expected. (Applicable to specific field conditions of sand (overwash), scour and swamping.) Sample calculation of average annual damage follows:

	Productivity Index (Yield) (%)	Net Income per Acre: Value of Production ($/ac)	Cost of Production ($/ac)	Net Income ($/ac)
1. Undamaged land	100	55.35	35.40	19.95
2. Damaged land (observed)	80	44.28	32.59	11.69
3. Reduction	20			

4. Rate of productivity decline $\frac{\text{Productivity reduction}}{\text{Period of damage}} = \frac{20}{40} = .5$

5. Expected productivity index at maximum decline   50 (% undamaged land)

6. No. years to reach maximum decline

   Present productivity index   80
   Productivity at maximum decline   50

   Difference 30 ÷ .5 = 60 years

7. Net income 60 years hence (50% productivity index) $2.86/ac

8. Rate of expected income loss

   Present income $11.69
   60 years hence   2.86
   $ 8.83 ÷ 60 = $.14717 per acre

9. Average annual damage without program

.14717 x 445.62012	65.48191
.14717 x 60 x 25 x .09506	20.98497
Average annual damage per acre	86.56688 x .04 = $3.46268

Observed present area damaged 300 acres

Average annual damage without program 300 x 3.46268 = $1,039

Discount factors - 4% interest

25	PV of 1 per annum, perpetuity
445.62012	PV of 1 increasing annuity - 60 years
.09506	PV of 1, 60 years hence

B. Field Condition II.

An increase in area damaged is expected and it is further expected that the present damaged area will further decline in productivity (yields) due to continued deposition. Also, no recovery of productivity without the program is expected. (Applicable to specific field conditions of overwash, scour and swamping.) Sample calculations of average annual damage follows:

1. Damage on newly damaged areas

a.	Productivity index at present (undamaged land)	100
b.	Productivity index at maximum decline	50
c.	Rate of productivity decline (see Item 4, Field Condition I)	.5
d.	No. years to reach maximum productivity decline	

Present productivity index	100
Productivity at maximum decline	50

Difference 50 ÷ .5 = 100

e. Net income 100 years hence - $2.86 per acre

f. Rate of expected income loss

Present income	$19.95
100 years hence	2.86
	$17.09 ÷ 100 = $.1709 per acre

g. Average annual damage without program

.1709 x 587.62985	100.42594
.1709 x 100 x 25 x .01980	8.45955
Average annual damage per acre	108.88549 x .04 = $4.35542

Annual rate of damage $\frac{300 \text{ pres. area damage}}{40 \text{ years}} = 7.5$ acres

New area subject to damage 112 acres

Years over which increases in area damaged can occur $\frac{112}{7.5} = 15$

4.35542 x 11.11839 x 7.5 = $363 average annual damage

Discount factors - 4% interest

587.62985	PV annuity, 100 years
25	PV annuity 1, perpetuity
.01980	PV 1, 100 years
11.11839	PV 1 per annum, 15 years

2. Average annual value of damage expected on previously damaged area (See 1 through 9 - Field Condition I) = $1,039

3. Total average annual damage $1,039 + $363 = $1,402.

C. Field Condition III.

An increase in area damaged is expected and recovery due to either natural processes or normal farm operations is a factor to be considered in the evaluation. (Applicable to specific field conditions of streambank and scour erosion, and overwash.) Inasmuch as recovery is usually a factor to be considered in streambank erosion damage, the following sample calculation is presented:

1. Productivity index and net income on undamaged land subject fo future damage.

100 $19.95 per acre (equivalent to net income without damage)

2. Productivity of land and net income at maximum recovery.

80 $11.69 per acre

3. Initial damage, productivity index and net income.

100 $0 per acre

4. Delay in beginning of recovery 5 years

5. Period required to reach maximum recovery 45 years
   (40 years after recovery begins)

6. Average annual rate of damage $\frac{\text{observed damage area}}{\text{no. years of occurrence}}$ = 3 acres

   Calculations:

   Net income values used

Initial damage	$ 0 per acre
5 years hence	0
32 years hence	3.43
45 years hence	11.69
Undamaged land	19.95

   Non-recoverable (1) $19.95 - 11.69 x 25 = $206.50

   Recoverable

(2) 11.69 - 3.43 x 17.87355	147.63552	n=32
(3) $\frac{11.69 - 3.43}{8}$ x 31.68138 x .28506	9.32460	n=8; n=32
(4) 3.43 - 0 x 4.45182	15.26974	n=5
(5) $\frac{3.43 - 0}{27}$ x 266.76036 x .82193	27.85458	n=5; n=27
PV of loss per acre	406.58444	

Average annual value of loss per acre 406.58444 x .04 = $16.26338.

Average annual damage when rate is 3 acres/year

Continuing in perpetuity 16.26338 x 25 x 3	$1,220
Continuing for 30 years 16.26338 x 17.29203 x 3	844

Discount factors - 4% interest

25	PV of 1 per annum, perpetuity
17.87355	PV of 1 per annum, 32 years
31.68138	PV of decreasing annuity - 8 years
4.45182	PV of 1 per annum, 5 years
.28506	PV of 1, 32 years
266.76036	PV of decreasing annuity, 27 years
.82193	PV of 1, 5 years

APPENDIX C - USE OF COMPOUND INTEREST AND ANNUITY TABLES IN BENEFIT AND COST EVALUATION

I. GENERAL

Compound interest and annuity tables are used in benefit-cost analysis when benefits are delayed for a significant period after costs are incurred, when benefits are not constant over the evaluation period, and when costs, expressed as capital or principal amounts, must be converted to an average annual cost.

Compound interest and annuity factors are functions of the interest rate and time. In the following examples and discussion it is assumed that the interest rate is 4 percent and the evaluation period is 50 years.

II. EXPLANATION OF ANNUITY AND INTEREST FACTORS

A. Present Value of 1.

This is the amount that must be invested now at compound interest to have a value of 1 in a given length of time. The interest on \$96,154 at 4% for one year is \$3,846 and the interest plus principal at the end of one year has an accumulated value of \$100,000. Thus, the present value of \$100,000 one year hence is \$96,154 or the present value of 1 is .96154 $\left(\frac{96154}{100,000}\right)$. (Column 2)

B. Compound Amount of 1 (Not shown on table).

This is the amount that will accumulate when a given amount is invested at compound interest for a given period of time and the interest is not withdrawn. The compound amount of \$1 in one year is \$1.04, in two years \$1.0816, etc. It is the reciprocal of the present value of 1. Hence, to determine the compound amount of 1 in 25 years, if the appropriate factor is not known, it can be determined by dividing 1 by .37512 = 2.666. Thus it can be said the \$2.666 in 25 years at 4% has a present value of 1 (\$2.666 x .37512) or the compound amount of \$1 in 25 years is \$2.666.

C. Amortization.

The extinguishing of a financial obligation in equal installments is called amortization. The amortization factor is the amount of the installment required to retire a debt of \$1 in a given length of time. For example, if a farmer borrows \$1,000 at 4 percent for three years, he must pay \$360.35 per year on the note as follows:

Revised 4/1/56

Year	Payment	Interest Charge	Payment on Principal	Unpaid Balance
0				$1,000.00
1	$ 360.35	$40.00	$ 320.35	679.65
2	360.35	27.19	333.16	346.49
3	360.35	13.86	346.49	
	$1,081.05	$81.05	$1,000.00	

D. Sinking Fund.

A sinking fund is the amount accumulated for the purpose of paying a debt or for accumulating capital. It is the principal component of $1,000 in the foregoing example (as distinguished from the interest component). Hence, the sinking fund factor is equal the amortization factor minus the interest factor (interest rate). The annuity necessary to accumulate a sinking fund of $1,000 in three years at 4% interest is $1,000 x .32035 (.36035 - .04) = $320.35. Hence, the investment of $320.35 per year at 4% interest will have a value at the end of three years (sinking fund) of $1,000.

E. Present Value of an Annuity of $1 Per Year.

The present value of $1 per year is the reciprocal of the amortization factor. It is a measure of the present value or worth of equal income amounts over a period of time. For example an annuity of $1,000 per year for ten years is worth $8,110.90 at 4 percent because $8,110.90 invested now will yield an annual income of $1,000 for ten years ($8,110.90 x .12329). Since the present value of an annuity of $1 per year is the reciprocal of the amortization factor, their product must always equal 1.

F. The Amount of an Annuity of $1 Per Year.

This is the amount that an investment of $1 per year will accumulate in a certain period of time at compound interest. It is the reciprocal of the sinking fund factor. The investment of $1,000 per year at 4% for ten years has a value at the end of ten years of $12,006. ($1,000 x 12.006). The present value of $12,006 ten years hence is $8,111 ($12,006 x .67556). This is the same value as obtained by multiplying the annuity ($1,000) by the present value of $1 per year (8.111).

G. The Present Value of an Increasing Annuity.

This is the measure of present value of an annuity that is not constant but increases uniformly over a period of time. In using this

factor it is important to note that the value of $1 (which is multiplied by the factor) is the annual rate of increase and not the total increase during the period. For example, an annuity increases uniformly over a ten-year period at which time it amounts to $1,000 per year. Hence, the annual rate of increase is $100 ($100 at the end of the first year, $200 at the end of the second year, etc.). The present value of such an annuity is $4,199 ($100 x 41.99). The increasing annuity factor is applicable where the beginning value is zero. If it is not zero (e.g., an increase from $500 to $1,500) then the $500 must be treated as a constant annuity. See problem 5.

H. The Present Value of a Decreasing Annuity.

This is the reverse of an increasing annuity and is handled in the same way. It should be noted that the present value of a decreasing annuity is greater than an equal increasing annuity. The reason for this is that a decreasing annuity has a high initial value whereas an increasing annuity has a high terminal value and when reduced to present value is subject to a greater discount.

III. EVALUATION PROBLEMS INVOLVING THE USE OF ANNUITY AND INTEREST FACTORS

The following problems illustrate the use of annuity factors. Although the examples used are hypothetical, they represent the type of problems frequently encountered in economic evaluations. Discount factors that may be used to short cut the calculations are shown.

A. Problem 1.

Floodwater damage under present flood plain conditions is estimated to be $1,000 annually. However, streambank erosion (not evaluated as a floodwater damage) is gradually destroying the land on which the floodwater damage occurs. Hence, the average annual floodwater damage will not be as great fifty years from now as it is at the present time. The problem is to determine how much the average annual floodwater damage should be discounted to reflect this condition. In this example it is assumed that the average annual floodwater damage fifty years hence will be $750.

<u>Solution</u>

The normal equivalent floodwater damage is made up of two annuities: (1) a constant annuity of $750 per year, and (2) a decreasing annuity of $250 in 50 years ($5/year).

The present value of a decreasing annuity of $5 per year for 50 years is $3565 ($5 x 712.945). The annual equivalent value of the decreasing annuity is $166 ($3565 x .04655). This is added to the $750

constant annuity and the answer, \$916 is the adjusted average annual floodwater damage.

Similar problems may be solved in a similar manner but the following short cut may be helpful. The rate of discounting a decreasing annuity is equal to:

$$\frac{\text{Col. } 7}{n \times \text{Col. } 4}$$

For this example the discount factor equals:

$$\frac{712.94538}{50 \times 21.48218} = .66376$$

It will probably save considerable time to calculate other factors for the most frequently used interest rates and time periods.

(The problem of evaluating the streambank erosion in this example will be considered in the following problem 2.)

B. Problem 2.

Streambank erosion is destroying land at the rate of 5 acres per year. The reduction in net income due to this loss is \$25 per acre or \$125 per year. This amount (\$125) is not a constant annuity but an increasing annuity; e.g., \$125 the first year, \$250 the second year, and \$6,250 the 50th year. What is the annual equivalent streambank erosion damage?

Solution

1. The present value of an increasing annuity of \$125 per year for 50 years is \$47,831 (\$125 x 382.646).

2. The annual equivalent value of \$47,831 is equal to \$2,227 (\$47,831 x .04655) which is the average annual streambank erosion damage.

From the foregoing it is determined that the annual equivalent value of an annuity increasing at a uniform rate for 50 years is equal to the annual rate of increase x 17.812 or the value in the 50th year x .35624.

C. Problem 3.

A damage or a benefit increases uniformly over a period of years and thereafter becomes constant. Determine the annual equivalent value (50 year evaluation period).

Given: The value of flood damage reduction benefits from land-treatment measures will amount to $3,000 annually after 15 years. During the first 15 years the annuity will increase at the rate of $200/year.

Solution

1. The present value of an increasing annuity of $200 per year equals $200 x 80.854 = $16,171.

2. The present value of a constant annuity or $3,000 for 35 years deferred 15 years equals $3,000 x 18.665 x .555 = $31,055.

3. Total present value (1 + 2) = $47,226.

4. Annual equivalent value equals $47,226 x .04655 = $2,198.

If the annuity increased the same as above but thereafter continued in perpetuity the annual equivalent value may be determined in the following manner: Multiply the present value of an annuity of 1 per year for the increasing period minus 1 year (in this case 14 years) add 1 and multiply by the rate of increase. For this example the computation is: (10.56312 + 1) x $200 = $2,313.

D. Problem 4.

A measure yields no benefit for a few years and then yields a continuing and constant benefit for the remainder of the evaluation period. What is the annual equivalent benefit?

Given: The value of forage from reseeding is estimated at $1,000 per year after the grass becomes established and is ready for use. It is estimated that 3 years are required for successful establishment. What is the annual equivalent benefit?

Solution

The present value of an annuity of $1,000 per year deferred three years equals $1,000 x .889 = $889.

It should be noted that in this case it is unnecessary to convert the annuity to a capital value, discount for the deferment period and reconvert to an annual equivalent value.

E. Problem 5.

The average annual floodwater damage under present conditions is estimated to be $1,000 annually. A study of sediment problems indicates that channel aggradation will increase this floodwater damage to $1,500 per year in 50 years. Although the increase in damage is a floodwater damage, it is properly classified as a sediment damage since sedimentation is the primary cause of the increase. What is the average annual sediment damage due to channel aggradation?

Solution

The increase in damage in the 50th year is $500. From problem 2 we know that the annual equivalent value of an increasing annuity is .35624 x the value in the 50th year ($500) equals $178. Hence, the average annual sediment damage is $178. The floodwater damage is still considered to be $1,000 per year.

F. Problem 6.

It may be impractical in some instances to design retarding structures to be fully effective for 50 years. If replacement is not practical, benefits will decline when sediment starts encroaching on the floodwater capacity. What adjustment in average annual benefits are necessary to reflect this situation?

Given: Average annual benefits attributable to a structure is $1,000 for 30 years, thereafter gradually declining at the rate of $20 per year to $600 per year in the 50th year.

Solution

There are several methods of solving this problem, but the following is probably the best. The value of the annuity is made up of three components: (1) a constant annuity of $600 for 50 years, (2) a constant annuity of $400 for 30 years and (3) a decreasing annuity of $20 per year for 20 years, and deferred 30 years. The present value of the annuity is solved in three steps as follows:

(1) $600 x 21.48218	=	$12,889
(2) $400 x 17.29203	=	6,916
(3) $20 x 160.24184 x .30832	=	988
Total present value		$20,793

The annual equivalent value is $20,793 x .04655 = $968.

F. Problem 7.

The installation cost must be converted to an annual cost for benefit-cost comparison. How is this done for these typical situations?

Given: A structure costs $10,000 and its life is at least 50 years. The costs are shared on the basis of anticipated benefits as follows: Federal cost, $7,000; non-Federal public cost, $1,000; private cost, $2,000.

Solution

On the basis of interest rates of 2½ percent for all public costs and 4 percent for private costs, the following amortization factors are applied to each of the above costs:

Agency or Group	Installation Cost	Amortization Factor	Annual Equivalent Cost
Federal	$ 7,000	.03526	$247
Non-Federal Public	1,000	.03526	35
Private	2,000	.04655	93
Total	$10,000		$375

Hence, the annual equivalent value of the installation cost of $10,000 is $375.

Given: A structure costs $10,000, but will last only 25 years. It can be replaced at the end of 25 years at approximately the same cost. Cost-sharing is the same as in the foregoing example.

Solution

By amortizing the cost in 25 years the resulting average annual cost is sufficient to amortize the second investment of $10,000 by the 50th year. Hence, the costs are amortized as follows:

Agency or Group	Installation Cost	Amortization Factor	Annual Equivalent Cost
Federal	$ 7,000	.054	$378
Non-Federal Public	1,000	.054	54
Private	2,000	.064	128
Total	$10,000		$560

Revised 4/1/56

Given: Same conditions as No. 2 except that replacement will cost 50 percent more than the initial installation or $15,000.

Solution

It is assumed that the $15,000 cost will be shared on the same basis as the initial cost of $10,000. Hence, each share of the cost of the second installation and its present worth is as follows:

Agency or Group	Installation Cost	Present Value of 1	Present Value of Installation Cost
Federal	$10,500	.539	$5,660
Non-Federal Public	1,500	.539	810
Private	3,000	.375	1,125
Total	$15,000		$7,595

The present value of the cost of the second installation is added to the initial cost and amortized on a 50-year basis as follows:

Agency or Group	Present Value of Installation Cost	Amortization Factor	Annual Equivalent Cost
Federal	$12,660	.03526	$446
Non-Federal Public	1,810	.03526	64
Private	3,125	.04655	145
Total	$17,595		$655

The foregoing problems do not include all of the different kinds of problems associated with benefit and cost evaluation. They should, however, provide a basis for applying needed techniques in solving other problems.

Compound Interest and Annuity Tables - 2½ Percent

No. of yrs. hence	Present value of 1	Amortization	Present value of an annuity of 1 per year	Amount of an annuity of 1 per year	Present value of an increasing annuity	Present value of a decreasing annuity
1	.97561	1.02500	.97561	1.00000	.97561	.97561
2	.95181	.51883	1.92742	2.02500	2.87924	2.90303
3	.92860	.35014	2.85602	3.07563	5.66504	5.75906
4	.90595	.26582	3.76197	4.15252	9.28884	9.52103
5	.88385	.21525	4.64583	5.25633	13.70811	14.16686
6	.86230	.18155	5.50813	6.38774	18.88189	19.67499
7	.84127	.15750	6.34939	7.54743	24.77075	26.02438
8	.82075	.13947	7.17014	8.73612	31.33672	33.19451
9	.80073	.12546	7.97087	9.95452	38.54328	41.16538
10	.78120	.11426	8.75206	11.20338	46.35526	49.91744
11	.76214	.10511	9.51421	12.48347	54.73885	59.43165
12	.74356	.09749	10.25776	13.79555	63.66152	69.68942
13	.72542	.09105	10.98318	15.14044	73.09199	80.67260
14	.70773	.08554	11.69091	16.51895	83.00017	92.36351
15	.69047	.08077	12.38138	17.93193	93.35715	104.74489
16	.67362	.07660	13.05500	19.38022	104.13515	117.79989
17	.65720	.07293	13.71220	20.86473	115.30747	131.51209
18	.64117	.06967	14.35336	22.38635	126.84846	145.86545
19	.62553	.06676	14.97889	23.94601	138.73348	160.84435
20	.61027	.06415	15.58916	25.54466	150.93890	176.43351
21	.59539	.06179	16.18455	27.18327	163.44201	192.61806
22	.58086	.05965	16.76541	28.86286	176.22104	209.38347
23	.56670	.05770	17.33211	30.58443	189.25507	226.71558
24	.55288	.05591	17.88499	32.34904	202.52408	244.60057
25	.53939	.05428	18.42438	34.15776	216.00885	263.02494
26	.52623	.05277	18.95061	36.01171	229.69095	281.97555
27	.51340	.05138	19.46401	37.91200	243.55274	301.43957
28	.50088	.05009	19.96489	39.85980	257.57732	321.40445
29	.48866	.04889	20.45355	41.85630	271.74850	341.85800
30	.47674	.04778	20.93029	43.90270	286.05078	362.78830
31	.46511	.04674	21.39541	46.00027	300.46934	384.18370
32	.45377	.04577	21.84918	48.15028	314.99000	406.03288
33	.44270	.04486	22.29188	50.35403	329.59919	428.32476
34	.43191	.04401	22.72379	52.61289	344.28397	451.04855
35	.42137	.04321	23.14516	54.92821	359.03196	474.19371
36	.41109	.04245	23.55625	57.30141	373.83134	497.74996
37	.40107	.04174	23.95732	59.73395	388.67082	521.70728
38	.39128	.04107	24.34860	62.22730	403.53964	546.05588
39	.38174	.04044	24.73034	64.78298	418.42756	570.78622
40	.37243	.03984	25.10278	67.40255	433.32478	595.88900
41	.36335	.03927	25.46612	70.08762	448.22200	621.35512
42	.35448	.03873	25.82061	72.83981	463.11036	647.17573
43	.34584	.03822	26.16645	75.66080	477.98144	673.34217
44	.33740	.03773	26.50385	78.55232	492.82720	699.84602
45	.32917	.03727	26.83302	81.51613	507.64005	726.67905
46	.32115	.03683	27.15417	84.55403	522.41276	753.83322
47	.31331	.03641	27.46748	87.66789	537.13847	781.30070
48	.30567	.03601	27.77315	90.85958	551.81068	809.07385

49	.29822	.03562	28.07137	94.13107	566.42326	837.14522
50	.29094	.03526	28.36231	97.48435	580.97037	865.50753
51	.28385	.03491	28.64616	100.92146	595.44652	894.15369
52	.27692	.03457	28.92308	104.44449	609.84651	923.07677
53	.27017	.03425	29.19325	108.05561	624.16546	952.27002
54	.26358	.03395	29.45683	111.75700	638.39874	981.72685
55	.25715	.03365	29.71398	115.55092	652.54202	1011.44083
56	.25088	.03337	29.96486	119.43969	666.59122	1041.40569
57	.24476	.03310	30.20962	123.42569	680.54252	1071.61530
58	.23879	.03284	30.44841	127.51133	694.39233	1102.06371
59	.23297	.03259	30.68137	131.69911	708.13730	1132.74508
60	.22728	.03235	30.90866	135.99159	721.77432	1163.65374
61	.22174	.03212	31.13040	140.39138	735.30047	1194.78414
62	.21633	.03190	31.34673	144.90116	748.71304	1226.13087
63	.21106	.03169	31.55778	149.52369	762.00953	1257.68865
64	.20591	.03148	31.76369	154.26179	775.18762	1289.45234
65	.20089	.03128	31.96458	159.11833	788.24518	1321.41692
66	.19599	.03109	32.16056	164.09629	801.18025	1353.57748
67	.19121	.03091	32.35177	169.19870	813.99104	1385.92925
68	.18654	.03073	32.53831	174.42866	826.67591	1418.46756
69	.18199	.03056	32.72030	179.78938	839.23339	1451.18786
70	.17755	.03040	32.89786	185.28411	851.66214	1484.08572
71	.17322	.03024	33.07108	190.91622	863.96097	1517.15680
72	.16900	.03008	33.24008	196.68912	876.12883	1550.39688
73	.16488	.02994	33.40495	202.60635	888.16478	1583.80183
74	.16085	.02979	33.56581	208.67151	900.06804	1617.36764
75	.15693	.02965	33.72274	214.88830	911.83790	1651.09038
76	.15310	.02952	33.87584	221.26050	923.47380	1684.96623
77	.14937	.02939	34.02521	227.79202	934.97527	1718.99144
78	.14573	.02926	34.17094	234.48682	946.34193	1753.16238
79	.14217	.02914	34.31311	241.34899	957.57354	1787.47549
80	.13870	.02903	34.45182	248.38271	968.66990	1821.92731
81	.13532	.02891	34.58714	255.59228	979.63095	1856.51445
82	.13202	.02880	34.71916	262.98209	990.45667	1891.10159
83	.12880	.02870	34.84796	270.55664	1001.14715	1926.08157
84	.12566	.02859	34.97362	278.32056	1011.70255	1961.05519
85	.12259	.02849	35.09621	286.27857	1022.12309	1996.15141
86	.11960	.02840	35.21582	294.43553	1032.40908	2031.36722
87	.11669	.02830	35.33251	302.79642	1042.56087	2066.69973
88	.11384	.02821	35.44635	311.36633	1052.57891	2102.14608
89	.11106	.02812	35.55741	320.15049	1062.46366	2137.70349
90	.10836	.02804	35.66577	329.15425	1072.21569	2173.36926
91	.10571	.02796	35.77148	338.38311	1081.83557	2209.14074
92	.10313	.02787	35.87462	347.84269	1091.32395	2245.01536
93	.10062	.02780	35.97524	357.53875	1100.68153	2280.99059
94	.09816	.02772	36.07340	367.47722	1109.90904	2317.06399
95	.09577	.02765	36.16917	377.66415	1119.00726	2353.23316
96	.09343	.02758	36.26261	388.10576	1127.97701	2389.49577
97	.09116	.02751	36.35376	398.80840	1136.81914	2425.84953
98	.08893	.02744	36.44269	409.77861	1145.53453	2462.29223
99	.08676	.02738	36.52946	421.02308	1154.12413	2498.82168
100	.08465	.02731	36.61411	432.54865	1162.58887	2535.43579
Perpetuity		.02500	40.00000		1640.00000	

Compound Interest and Annuity Tables - 3 Percent

No. of yrs. hence	Present value of 1	Amortization	Present value of an annuity of 1 per year	Amount of an annuity of 1 per year	Present value of an increasing annuity	Present value of a decreasing annuity
1	.97087	1.03000	.97087	1.00000	.97087	.97087
2	.94260	.52261	1.91347	2.03000	2.85607	2.88434
3	.91514	.35353	2.82861	3.09090	5.60149	5.71295
4	.88849	.26903	3.71710	4.18363	9.15544	9.43005
5	.86261	.21835	4.57971	5.30914	13.46848	14.00976
6	.83748	.18460	5.41719	6.46841	18.49339	19.42695
7	.81309	.16051	6.23028	7.66246	24.18503	25.65723
8	.76941	.14246	7.01969	8.89234	30.50030	32.67693
9	.76642	.12843	7.78611	10.15911	37.39805	40.46304
10	.74409	.11723	8.53020	11.46388	44.83899	48.99324
11	.72242	.10808	9.25262	12.80780	52.78563	58.24586
12	.70138	.10046	9.95400	14.19203	61.20219	68.19987
13	.68095	.09403	10.63496	15.61779	70.05455	78.83482
14	.66112	.08853	11.29607	17.08632	79.31020	90.13090
15	.64186	.08377	11.93794	18.59891	88.93813	102.06883
16	.62317	.07961	12.56110	20.15688	98.90880	114.62993
17	.60502	.07595	13.16612	21.76159	109.19408	127.79605
18	.58739	.07271	13.75351	23.41444	119.76718	141.54956
19	.57029	.06981	14.32380	25.11687	130.60262	155.87336
20	.55368	.06722	14.87747	26.87037	141.67613	170.75084
21	.53755	.06487	15.41502	28.67649	152.96467	186.16586
22	.52189	.06275	15.93692	30.53678	164.44630	202.10278
23	.50669	.06081	16.44361	32.45288	176.10021	218.54639
24	.49193	.05905	16.93554	34.42647	187.90662	235.48193
25	.47761	.05743	17.41315	36.45926	199.84676	252.89508
26	.46369	.05594	17.87684	38.55304	211.90283	270.77192
27	.45019	.05456	18.32703	40.70963	224.05793	289.09895
28	.43708	.05329	18.76441	42.93092	236.29708	307.86306
29	.42435	.05211	19.18845	45.21885	248.60212	327.05151
30	.41199	.05102	19.60044	47.57542	260.96173	346.65196
31	.39999	.05000	20.00043	50.00268	273.36133	366.65238
32	.38834	.04905	20.38877	52.50276	285.78811	387.04115
33	.37703	.04816	20.76579	55.07784	298.22998	407.80694
34	.36604	.04732	21.13184	57.73018	310.67551	428.93878
35	.35538	.04654	21.48722	60.46208	323.11393	450.42600
36	.34503	.04580	21.83225	63.27594	335.53509	472.25825
37	.33498	.04511	22.16724	66.17422	347.92946	494.42549
38	.32523	.04446	22.49246	69.15945	360.28805	516.91795
39	.31575	.04384	22.80822	72.23423	372.60244	539.72616
40	.30656	.04326	23.11477	75.40126	384.86472	562.84093
41	.29763	.04271	23.41240	78.66330	397.06746	586.25333
42	.28896	.04219	23.70136	82.02320	409.20375	609.95469
43	.28054	.04170	23.98190	85.48389	421.26710	633.93660
44	.27237	.04123	24.25427	89.04841	433.25146	658.19087
45	.26444	.04079	24.51871	92.71986	445.15119	682.70958
46	.25674	.04036	24.77545	96.50146	456.96108	707.48503
47	.24926	.03996	25.02471	100.39650	468.67624	732.50974
48	.24200	.03958	25.26671	104.40840	480.29218	757.77645

49	.23495	.03921	25.50166	108.54065	491.80474	783.27810
50	.22811	.03887	25.72976	112.79687	503.21100	809.00787
51	.22146	.03853	25.95123	117.18077	514.50472	834.95909
52	.21501	.03822	26.16624	121.69620	525.68539	861.12534
53	.20875	.03791	26.37499	126.34708	536.74915	887.50033
54	.20267	.03763	26.57766	131.13749	547.69334	914.07799
55	.19677	.03735	26.77443	136.07162	558.51554	940.85242
56	.19104	.03708	26.96546	141.15377	569.21356	967.81789
57	.18547	.03683	27.15094	146.38838	579.78546	994.96882
58	.18007	.03659	27.33101	151.78003	590.22951	1022.29982
59	.17483	.03636	27.50583	157.33343	600.54419	1049.80566
60	.16973	.03613	27.67556	163.05344	610.72817	1077.48122
61	.16479	.03592	27.84035	168.94504	620.78033	1105.32157
62	.15999	.03571	28.00034	175.01339	630.69967	1133.32192
63	.15533	.03552	28.15567	181.26379	640.48547	1161.47759
64	.15081	.03533	28.30648	187.70171	650.13703	1189.78407
65	.14641	.03515	28.45289	194.33276	659.65389	1218.23696
66	.14215	.03497	28.59504	201.16274	669.03571	1246.83200
67	.13801	.03480	28.73305	208.19762	678.28228	1275.56505
68	.13399	.03464	28.86704	215.44355	687.39353	1304.43209
69	.13009	.03449	28.99712	222.90686	696.36948	1333.42921
70	.12630	.03434	29.12342	230.59406	705.21029	1362.55263
71	.12262	.03419	29.24604	238.51189	713.91623	1391.79867
72	.11905	.03405	29.36509	246.66724	722.48764	1421.16376
73	.11558	.03392	29.48067	255.06726	730.92498	1450.64442
74	.11221	.03379	29.59288	263.71928	739.22878	1480.23731
75	.10895	.03367	29.70183	272.63086	747.39967	1509.93914
76	.10577	.03355	29.80760	281.80978	755.43835	1539.74673
77	.10269	.03343	29.81029	291.26407	763.34558	1569.65702
78	.09970	.03332	30.00999	301.00200	771.12220	1599.66701
79	.09680	.03321	30.10679	311.03206	778.76912	1629.77380
80	.09398	.03311	30.20076	321.36302	786.28729	1659.97456
81	.09124	.03301	30.29200	332.00391	793.67772	1690.26657
82	.08858	.03292	30.38059	342.96403	800.94148	1720.64715
83	.08600	.03282	30.46659	354.25295	808.07967	1751.11374
84	.08350	.03273	30.55009	365.88054	815.09346	1781.66383
85	.08107	.03265	30.63115	377.85695	821.98402	1812.29498
86	.07870	.03256	30.70986	390.19266	828.75260	1843.00483
87	.07641	.03248	30.78627	402.89844	835.40044	1873.79110
88	.07419	.03240	30.86045	415.98539	841.92884	1904.65155
89	.07203	.03233	30.93248	429.46496	848.33912	1935.58403
90	.06993	.03226	31.00241	443.34890	854.63262	1966.58644
91	.06789	.03219	31.07030	457.64937	860.81071	1997.65674
92	.06591	.03212	31.13621	472.37885	866.87476	2028.79295
93	.06399	.03205	31.20021	487.55022	872.82619	2059.99316
94	.06213	.03199	31.26234	503.17672	878.66640	2091.25549
95	.06032	.03193	31.32266	519.27203	884.39683	2122.57815
96	.05856	.03187	31.38122	535.85019	890.01892	2153.95937
97	.05686	.03181	31.43808	552.92569	895.53412	2185.39744
98	.05520	.03175	31.49328	570.51346	900.94388	2216.89072
99	.05359	.03170	31.54687	588.62887	906.24967	2248.43759
100	.05203	.03165	31.59891	607.28773	911.45295	2280.03650
Perpetuity		.03000	33.33333		1144.44444	

Compound Interest and Annuity Tables - 4 Percent

No. of yrs. hence	Present value of 1	Amortization	Present value of an annuity of 1 per year	Amount of an annuity of 1 per year	Present value of an increasing annuity	Present value of a decreasing annuity
1	.96154	1.04000	.96154	1.00000	.96154	.96154
2	.92456	.53020	1.88609	2.04000	2.81065	2.84763
3	.88900	.36035	2.77509	3.12160	5.47764	5.62272
4	.85480	.27549	3.62990	4.24646	8.89686	9.25262
5	.82193	.22463	4.45182	5.41632	13.00649	13.70444
6	.79031	.19076	5.24214	6.63298	17.74838	18.94658
7	.75992	.16661	6.00205	7.89829	23.06780	24.94863
8	.73069	.14853	6.73274	9.21423	28.91333	31.68138
9	.70259	.13449	7.43533	10.58280	35.23661	39.11671
10	.67556	.12329	8.11090	12.00611	41.99225	47.22761
11	.64958	.11415	8.76048	13.48635	49.13764	55.98808
12	.62460	.10655	9.38507	15.02581	56.63280	65.37316
13	.60057	.10014	9.98565	16.62684	64.44027	75.35880
14	.57748	.09467	10.56312	18.29191	72.52492	85.92193
15	.55526	.08994	11.11839	20.02359	80.85389	97.04031
16	.53391	.08582	11.65230	21.82453	89.39642	108.69261
17	.51337	.08220	12.16567	23.69751	98.12376	120.85828
18	.49363	.07899	12.65930	25.64541	107.00907	133.51758
19	.47464	.07614	13.13394	27.67123	116.02727	146.65152
20	.45639	.07358	13.59033	29.77808	125.15501	160.24184
21	.43883	.07128	14.02916	31.96920	134.37052	174.27100
22	.42196	.06920	14.45112	34.24797	143.65353	188.72212
23	.40573	.06731	14.85684	36.61789	152.98524	203.57896
24	.39012	.06559	15.24696	39.08260	162.34816	218.82592
25	.37512	.06401	15.62208	41.64591	171.72608	234.44800
26	.36069	.06257	15.98277	44.31174	181.10399	250.43077
27	.34682	.06124	16.32959	47.08421	190.46804	266.76036
28	.33348	.06001	16.66306	49.96758	199.80541	283.42342
29	.32065	.05888	16.98371	52.96629	209.10430	300.40713
30	.30832	.05783	17.29203	56.08494	218.35386	317.69917
31	.29646	.05686	17.58849	59.32834	227.54413	335.28766
32	.28506	.05595	17.87355	62.70147	236.66599	353.16121
33	.27409	.05510	18.14765	66.20953	245.71110	371.30886
34	.26355	.05431	18.41120	69.85791	254.67187	389.72006
35	.25342	.05358	18.66461	73.65222	263.54111	408.38467
36	.24367	.05289	18.90828	77.59831	272.31348	427.29295
37	.23430	.05224	19.14258	81.70225	280.98246	446.43553
38	.22529	.05163	19.36786	85.97034	289.54331	465.80339
39	.21662	.05106	19.58448	90.40915	297.99151	485.38788
40	.20829	.05052	19.79277	95.02552	306.32307	505.18065
41	.20028	.05002	19.99305	99.82654	314.53447	525.17370
42	.19257	.04954	20.18563	104.81960	322.62261	545.35933
43	.18517	.04909	20.37079	110.01238	330.58485	565.73013
44	.17805	.04866	20.54884	115.41288	338.41888	586.27897
45	.17120	.04826	20.72004	121.02939	346.12281	606.99901
46	.16461	.04788	20.88465	126.87057	353.69505	627.88366
47	.15828	.04752	21.04294	132.94539	361.13433	648.92660
48	.15219	.04718	21.19513	139.26321	368.43968	670.12173

49	.14634	.04686	21.34147	145.83373	375.61040	691.46320
50	.14071	.04655	21.48218	152.66708	382.64603	712.94538
51	.13530	.04626	21.61749	159.77377	389.54636	734.56287
52	.13010	.04598	21.74758	167.16472	396.31139	756.31045
53	.12509	.04572	21.87267	174.85131	402.94131	778.18313
54	.12028	.04547	21.99296	182.84536	409.43653	800.17608
55	.11566	.04523	22.10861	191.15917	415.79758	822.28470
56	.11121	.04500	22.21982	199.80554	422.02518	844.50451
57	.10693	.04479	22.32675	208.79776	428.12019	866.83126
58	.10282	.04458	22.42957	218.14967	434.08360	889.26083
59	.09886	.04439	22.52843	227.87566	439.91650	911.78926
60	.09506	.04420	22.62349	237.99069	445.62012	934.41275
61	.09140	.04402	22.71489	248.51031	451.19578	957.12764
62	.08789	.04385	22.80278	259.45073	456.64488	979.93043
63	.08451	.04369	22.88729	270.82875	461.96891	1002.81772
64	.08126	.04354	22.96855	282.66190	467.16942	1025.78627
65	.07813	.04339	23.04668	294.96838	472.24805	1048.83295
66	.07513	.04325	23.12181	307.76712	477.20647	1071.95476
67	.07224	.04311	23.19405	321.07780	482.04642	1095.14881
68	.06946	.04299	23.26351	334.92091	486.76968	1118.41231
69	.06679	.04286	23.33030	349.31775	491.37807	1141.74261
70	.06422	.04275	23.39451	364.29046	495.87342	1165.13713
71	.06175	.04263	23.45626	379.86208	500.25763	1188.59339
72	.05937	.04252	23.51564	396.05656	504.53259	1212.10903
73	.05709	.04242	23.57273	412.89882	508.70022	1235.68176
74	.05490	.04232	23.62762	430.41478	512.76245	1259.30938
75	.05278	.04223	23.68041	448.63137	516.72122	1282.98979
76	.05075	.04214	23.73116	467.57662	520.57849	1306.72095
77	.04880	.04205	23.77996	487.27969	524.33621	1330.50092
78	.04692	.04197	23.82689	507.77087	527.99632	1354.32780
79	.04512	.04189	23.87201	529.08171	531.56077	1378.19981
80	.04338	.04181	23.91539	551.24498	535.03152	1402.11520
81	.04172	.04174	23.95711	574.29478	538.41049	1426.07231
82	.04011	.04167	23.99722	598.26657	541.69961	1450.06953
83	.03857	.04160	24.03579	623.19723	544.90079	1474.10532
84	.03709	.04154	24.07287	649.12512	548.01594	1498.17819
85	.03566	.04148	24.10853	676.09012	551.04694	1522.28672
86	.03429	.04142	24.14282	704.13373	553.99565	1546.42954
87	.03297	.04136	24.17579	733.29908	556.86391	1570.60533
88	.03170	.04131	24.20749	763.63104	559.65355	1594.81281
89	.03048	.04126	24.23797	795.17628	562.36639	1619.05078
90	.02931	.04121	24.26728	827.98333	565.00419	1643.31806
91	.02818	.04116	24.29546	862.10267	567.56871	1667.61352
92	.02710	.04111	24.32256	897.58677	570.06170	1691.93608
93	.02606	.04107	24.34861	934.49024	572.48486	1716.28469
94	.02505	.04103	24.37367	972.86985	574.83988	1740.65835
95	.02409	.04099	24.39776	1012.78465	577.12841	1765.05611
96	.02316	.04095	24.42092	1054.29603	579.35208	1789.47703
97	.02227	.04091	24.44319	1097.46788	581.51250	1813.92022
98	.02142	.04088	24.46461	1142.36659	583.61124	1838.38483
99	.02059	.04084	24.48520	1189.06125	585.64985	1862.87003
100	.01980	.04081	24.50500	1237.62370	587.62985	1887.37502
Perpetuity		.04000	25.00000		650.00000	

Compound Interest and Annuity Tables - 5 Percent

No. of yrs. hence	Present value of 1	Amortization	Present value of an annuity of 1 per year	Amount of an annuity of 1 per year	Present value of an increasing annuity	Present value of a decreasing annuity
1	.95238	1.05000	.95238	1.00000	.95238	.95238
2	.90703	.53780	1.85941	2.05000	2.76644	2.81179
3	.86384	.36721	2.72325	3.15250	5.35795	5.53504
4	.82270	.28201	3.54595	4.31013	8.64876	9.08099
5	.78353	.23097	4.32948	5.52563	12.56639	13.41047
6	.74622	.19702	5.07569	6.80191	17.04369	18.48616
7	.71068	.17282	5.78637	8.14201	22.01846	24.27253
8	.67684	.15472	6.46321	9.54911	27.43317	30.73574
9	.64461	.14069	7.10782	11.02656	33.23465	37.84356
10	.61391	.12950	7.72173	12.57789	39.37378	45.56529
11	.58468	.12039	8.30641	14.20679	45.80525	53.87170
12	.55684	.11283	8.86325	15.91713	52.48730	62.73495
13	.53032	.10646	9.39357	17.71298	59.38148	72.12852
14	.50507	.10102	9.89864	19.59863	66.45243	82.02716
15	.48102	.09634	10.37966	21.57856	73.66769	92.40682
16	.45811	.09227	10.83777	23.65749	80.99747	103.24459
17	.43630	.08870	11.27407	25.84037	88.41452	114.51866
18	.41552	.08555	11.68959	28.13238	95.89389	126.20825
19	.39573	.08275	12.08532	30.53900	103.41283	138.29357
20	.37689	.08024	12.46221	33.06595	110.95062	150.75578
21	.35894	.07800	12.82115	35.71925	118.48841	163.57693
22	.34185	.07597	13.16300	38.50521	126.00911	176.73993
23	.32557	.07414	13.48857	41.43048	133.49725	190.22850
24	.31007	.07247	13.79864	44.50200	140.93888	204.02714
25	.29530	.07095	14.09394	47.72800	148.32145	218.12108
26	.28124	.06956	14.37519	51.11345	155.63371	232.49626
27	.26785	.06829	14.64303	54.66913	162.86561	247.13929
28	.25509	.06712	14.89813	58.40258	170.00824	262.03742
29	.24295	.06605	15.14107	62.32271	177.05368	277.17849
30	.23138	.06505	15.37245	66.43885	183.99500	292.55094
31	.22036	.06413	15.59281	70.76079	190.82615	308.14375
32	.20987	.06328	15.80268	75.29883	197.54186	323.94643
33	.19987	.06249	16.00255	80.06377	204.13766	339.94898
34	.19035	.06176	16.19290	85.06696	210.60972	356.14188
35	.18129	.06107	16.37419	90.32031	216.95488	372.51607
36	.17266	.06043	16.54685	95.83632	223.17055	389.06292
37	.16444	.05984	16.71129	101.62814	229.25467	405.77421
38	.15661	.05928	16.86789	107.70955	235.20567	422.64210
39	.14915	.05876	17.01704	114.09502	241.02244	439.65914
40	.14205	.05828	17.15909	120.79977	246.70427	456.81823
41	.13528	.05782	17.29437	127.83976	252.25081	474.11260
42	.12884	.05739	17.42321	135.23175	257.66208	491.53581
43	.12270	.05699	17.54591	142.99334	262.93837	509.08172
44	.11686	.05662	17.66277	151.14301	268.08027	526.74449
45	.11130	.05626	17.77407	159.70016	273.08861	544.51856
46	.10600	.05593	17.88007	168.68516	277.96446	562.39863
47	.10095	.05561	17.98102	178.11942	282.70907	580.37965
48	.09614	.05532	18.07716	188.02539	287.32389	598.45681

49	.09156	.05504	18.16872	198.42666	291.81052	616.62553
50	.08720	.05478	18.25593	209.34800	296.17071	634.88145
51	.08305	.05453	18.33898	220.81540	300.40632	653.22043
52	.07910	.05429	18.41807	232.85617	304.51933	671.63850
53	.07533	.05407	18.49340	245.49897	308.51181	690.13190
54	.07174	.05386	18.56515	258.77392	312.38592	708.69704
55	.06833	.05367	18.63347	272.71262	316.14387	727.33051
56	.06507	.05348	18.69854	287.34825	319.78794	746.02905
57	.06197	.05330	18.76052	302.71566	323.32047	764.78957
58	.05902	.05314	18.81954	318.85144	326.74379	783.60911
59	.05621	.05298	18.87575	335.79402	330.06032	802.48486
60	.05354	.05283	18.92929	353.58372	333.27245	821.41415
61	.05099	.05269	18.98028	372.26290	336.38261	840.39443
62	.04856	.05255	19.02883	391.87605	339.39323	859.42326
63	.04625	.05242	19.07508	412.46985	342.30672	878.49834
64	.04404	.05230	19.11912	434.09334	345.12553	897.61746
65	.04195	.05219	19.16107	456.79801	347.85205	916.77853
66	.03995	.05208	19.20102	480.63791	350.48868	935.97955
67	.03805	.05198	19.23907	505.66981	353.03781	955.21862
68	.03623	.05188	19.27530	531.95330	355.50179	974.49392
69	.03451	.05179	19.30981	559.55096	357.88294	993.80373
70	.03287	.05170	19.34268	588.52851	360.18358	1013.14641
71	.03130	.05162	19.37398	618.95494	362.40595	1032.52039
72	.02981	.05154	19.40379	650.90268	364.55232	1051.92418
73	.02839	.05146	19.43218	684.44782	366.62486	1071.35636
74	.02704	.05139	19.45922	719.67021	368.62575	1090.81558
75	.02575	.05132	19.48497	756.65372	370.55712	1110.30055
76	.02453	.05126	19.50950	795.48640	372.42103	1129.81005
77	.02336	.05120	19.53285	836.26072	374.21955	1149.34290
78	.02225	.05114	19.55510	879.07376	375.95467	1168.89800
79	.02119	.05108	19.57628	924.02745	377.62835	1188.47428
80	.02018	.05103	19.59646	971.22882	379.24251	1208.07074
81	.01922	.05098	19.61568	1020.79026	380.79902	1227.68642
82	.01830	.05093	19.63398	1072.82978	382.29971	1247.32040
83	.01743	.05089	19.65141	1127.47126	383.74637	1266.97181
84	.01660	.05084	19.66801	1184.84483	385.14074	1286.63982
85	.01581	.05080	19.68382	1245.08707	386.48452	1306.32364
86	.01506	.05076	19.69887	1308.34142	387.77937	1326.02251
87	.01434	.05073	19.71321	1374.75849	389.02690	1345.73572
88	.01366	.05069	19.72687	1444.49642	390.22867	1365.46259
89	.01301	.05066	19.73987	1517.72124	391.38623	1385.20246
90	.01239	.05063	19.75226	1594.60730	392.50105	1404.95472
91	.01180	.05060	19.76406	1675.33767	393.57459	1424.71878
92	.01124	.05057	19.77529	1760.10455	394.60823	1444.49407
93	.01070	.05054	19.78599	1849.10978	395.60336	1464.28006
94	.01019	.05051	19.79619	1942.56527	396.56129	1484.07624
95	.00971	.05049	19.80589	2040.69353	397.48331	1503.88213
96	.00924	.05047	19.81513	2143.72821	398.37067	1523.69726
97	.00880	.05044	19.82394	2251.91462	399.22457	1543.52120
98	.00838	.05042	19.83232	2365.51035	400.04620	1563.35352
99	.00798	.05040	19.84031	2484.78586	400.83669	1583.19382
100	.00760	.05038	19.84791	2610.02516	401.59713	1603.04173
Perpetuity		.05000	20.00000		420.00000	

Compound Interest and Annuity Tables - 6 Percent

No. of yrs. hence	Present value of 1	Amortization	Present value of an annuity of 1 per year	Amount of an annuity of 1 per year	Present value of an increasing annuity	Present value of a decreasing annuity
1	.94340	1.06000	.94340	1.00000	.94340	.94340
2	.89000	.54544	1.83339	2.06000	2.72339	2.77679
3	.83962	.37411	2.67301	3.18300	5.24225	5.44980
4	.79209	.28859	3.46511	4.37462	8.41062	8.91490
5	.74726	.23740	4.21236	5.63709	12.14691	13.12726
6	.70496	.20336	4.91732	6.97532	16.37668	18.04458
7	.66506	.17914	5.58238	8.39384	21.03208	23.62696
8	.62741	.16104	6.20979	9.89747	26.05137	29.83675
9	.59190	.14702	6.80169	11.49132	31.37846	36.63844
10	.55839	.13588	7.36009	13.18079	36.96241	43.99853
11	.52679	.12679	7.88687	14.97164	42.75707	51.88540
12	.49697	.11928	8.38384	16.86994	48.72070	60.26924
13	.46884	.11296	8.85268	18.88214	54.81561	69.12192
14	.44230	.10758	9.29498	21.01507	61.00782	78.41690
15	.41727	.10296	9.71225	23.27597	67.26680	88.12915
16	.39365	.09895	10.10590	25.67253	73.56514	98.23505
17	.37136	.09544	10.47726	28.21288	79.87834	108.71231
18	.35034	.09236	10.82760	30.90565	86.18452	119.53991
19	.33051	.08962	11.15812	33.75999	92.46427	130.69803
20	.31180	.08718	11.46992	36.78559	98.70037	142.16795
21	.29416	.08500	11.76408	39.99273	104.87763	153.93203
22	.27751	.08305	12.04158	43.39229	110.98274	165.97361
23	.26180	.08128	12.30338	46.99583	117.00408	178.27699
24	.24698	.07968	12.55036	50.81558	122.93156	190.82735
25	.23300	.07823	12.78336	54.86451	128.75653	203.61071
26	.21981	.07690	13.00317	59.15638	134.47159	216.61388
27	.20737	.07570	13.21053	63.70577	140.07052	229.82441
28	.19563	.07459	13.40616	68.52811	145.54817	243.23057
29	.18456	.07358	13.59072	73.63980	150.90031	256.82129
30	.17411	.07265	13.76483	79.05817	156.12362	270.58612
31	.16425	.07179	13.92909	84.80168	161.21552	284.51520
32	.15496	.07100	14.08404	90.88978	166.17415	298.59924
33	.14619	.07027	14.23023	97.34316	170.99830	312.82947
34	.13791	.06960	14.36814	104.18375	175.68729	327.19761
35	.13011	.06897	14.49825	111.43478	180.24098	341.69586
36	.12274	.06839	14.62099	119.12087	184.65964	356.31685
37	.11579	.06786	14.73678	127.26812	188.94399	371.05363
38	.10924	.06736	14.84602	135.90421	193.09507	385.89965
39	.10306	.06689	14.94907	145.05846	197.11423	400.84872
40	.09722	.06646	15.04630	154.76197	201.00312	415.89502
41	.09172	.06606	15.13802	165.04768	204.76560	431.03304
42	.08653	.06568	15.22454	175.95054	208.39775	446.25758
43	.08163	.06533	15.30617	187.50758	211.90783	461.56375
44	.07701	.06501	15.38318	199.75803	215.29622	476.94693
45	.07265	.06470	15.45583	212.74351	218.56548	492.40276
46	.06854	.06441	15.52437	226.50812	221.71822	507.92713
47	.06466	.06415	15.58903	241.09861	224.75716	523.51616
48	.06100	.06390	15.65003	256.56453	227.68508	539.16619

49	.05755	.06366	15.70757	272.95840	230.50482	554.87376
50	.05429	.06344	15.76186	290.33590	233.21924	570.63562
51	.05122	.06324	15.81308	308.75606	235.83122	586.44870
52	.04832	.06305	15.86139	328.28142	238.34368	602.31009
53	.04558	.06287	15.90697	348.97831	240.75950	618.21706
54	.04300	.06270	15.94998	370.91701	243.08158	634.16704
55	.04057	.06254	15.99054	394.17203	245.31279	650.15758
56	.03827	.06239	16.02881	418.82235	247.45597	666.18639
57	.03610	.06225	16.06492	444.95169	249.51395	682.25131
58	.03406	.06212	16.09898	472.64879	251.48950	698.35029
59	.03213	.06199	16.13111	502.00772	253.38586	714.48140
60	.03031	.06188	16.16143	533.12818	255.20422	730.64283
61	.02860	.06177	16.19003	566.11587	256.94872	746.83286
62	.02698	.06166	16.21701	601.08282	258.62146	763.04986
63	.02545	.06157	16.24246	638.14779	260.22497	779.29232
64	.02401	.06148	16.26647	677.43666	261.76172	795.55879
65	.02265	.06139	16.28912	719.08286	263.23415	811.84791
66	.02137	.06131	16.31049	763.22783	264.64459	828.15840
67	.02016	.06123	16.33065	810.02150	265.99536	844.48905
68	.01902	.06116	16.34967	859.62279	267.28870	860.83872
69	.01794	.06110	16.36762	912.20016	268.52676	877.20634
70	.01693	.06103	16.38454	967.93217	269.71168	893.59088
71	.01597	.06097	16.40051	1027.00810	270.84549	909.99139
72	.01507	.06092	16.41558	1089.62859	271.93019	926.40697
73	.01421	.06087	16.42979	1156.00630	272.96771	942.83676
74	.01341	.06082	16.44320	1226.36668	273.95991	959.27996
75	.01265	.06077	16.45585	1300.94868	274.90859	975.73581
76	.01193	.06072	16.46778	1380.00560	275.81551	992.20359
77	.01126	.06068	16.47904	1463.80594	276.68235	1008.68263
78	.01062	.06064	16.48966	1552.63429	277.51074	1025.17229
79	.01002	.06061	16.49968	1646.79235	278.30227	1041.67197
80	.00945	.06057	16.50913	1746.59989	279.05844	1058.18110
81	.00892	.06054	16.51805	1852.39588	279.78073	1074.69915
82	.00841	.06051	16.52646	1964.53964	280.47054	1091.22561
83	.00794	.06048	16.53440	2083.41202	281.12925	1107.76001
84	.00749	.06045	16.54188	2209.41674	281.75815	1124.30189
85	.00706	.06043	16.54895	2342.98174	282.35853	1140.85084
86	.00666	.06040	16.55561	2484.56065	282.93158	1157.40645
87	.00629	.06038	16.56190	2634.63428	283.47848	1173.96835
88	.00593	.06036	16.56783	2793.71234	284.00035	1190.53618
89	.00559	.06034	16.57342	2962.33508	284.49828	1207.10960
90	.00528	.06032	16.57870	3141.07519	284.97331	1223.68830
91	.00498	.06030	16.58368	3330.53970	285.42642	1240.27198
92	.00470	.06028	16.58838	3531.37208	285.85858	1256.86036
93	.00443	.06027	16.59281	3744.25441	286.27072	1273.45317
94	.00418	.06025	16.59699	3969.90967	286.66370	1290.05016
95	.00394	.06024	16.60093	4209.10425	287.03839	1306.65109
96	.00372	.06022	16.60465	4462.65050	287.39559	1323.25574
97	.00351	.06021	16.60816	4731.40953	287.73607	1339.86390
98	.00331	.06020	16.61147	5016.29411	288.06060	1356.47537
99	.00312	.06019	16.61460	5318.27175	288.36988	1373.08997
100	.00295	.06018	16.61755	5638.36806	288.66461	1389.70752
Perpetuity		.06000	16.66667		294.44444	

APPENDIX D

PRICE DATA

(To be furnished at a later date)